

## IBM CUTS RESEARCH IN PHYSICAL SCIENCES AT YORKTOWN HEIGHTS AND ALMADEN

The other shoe has dropped. With the troubles of IBM dominating the nation's business pages during the past year, and with the company cutting total staff by about 20% in 1992 and 1993, it was inevitable that research would take a hit. Given the industry-wide shift in computing and communications research away from materials and hardware toward software and mathematical modeling, it also was inevitable that traditional research in the physical sciences would be disproportionately affected. And so it is no surprise to learn that the number of physicists working in physics at IBM Research is slated to be cut this year by about one third—from approximately 330 to perhaps 220.

IBM Research's total staff already has been reduced by attrition from about 3200 to about 3000, and it is due to be cut about 12% more. All of IBM's research labs are involved, but the very distinguished Zurich laboratory will be less affected, while cuts in research will go further at the Thomas J. Watson Research Center in Yorktown Heights, New York, and the Almaden Research Center in San Jose, California. (The staff at Zurich typically has 30–40 physicists, and four of them have won Nobel Prizes in physics in the last decade—Georg Bednorz, Gerd Binnig, Alex Müller and Heinrich Rohrer.)

Earlier this year all staff of IBM Research were invited to apply to participate in an early retirement or early departure incentive plan, the Research Transition Option, which provides two weeks' pay for every year of service. Researchers had until 30 April to announce their wishes and IBM until 28 May to accept or reject RTO applications. IBM can refuse applications where it deems an individual or an individual's research too valuable an asset to lose. Many physicists not wishing to leave are being encouraged to shift into work more urgently needed by the company, such as software development.

In some cases IBM has offered



**The Thomas J. Watson Research Center**, the headquarters of IBM Research, is located in Yorktown Heights, New York, 35 miles north of New York City. Completed in 1961, the building was designed by Eero Saarinen.

equipment, including in one case a molecular beam epitaxy machine, to institutions that departing physicists are joining. Those staying at Yorktown Heights will have to do without the internal service organization that has provided sample analysis and materials characterization.

Among those expected to take advantage of the RTO are some of IBM's best known researchers, including IBM Fellows Alan Fowler, known primarily for his work in electron transport; Richard Garwin, whose interests have ranged from experimental particle physics to touch-screen and laser-printer technology and from computation to arms control and defense policy; Benoit Mandelbrot of chaos theory, fractal geometry and the Mandelbrot set (see page 109); and Jerry Woodall, known mainly for making the first GaAs–GaAlAs heterojunctions using liquid-phase epitaxy, who is taking a distinguished professorship at Purdue.

Also to be taken into account, in

forming a picture of what IBM Research will look like in one year versus what it looked like a couple of years back, are those who have departed in recent years more or less independently of the current situation: for example, the Nobelist Leo Esaki, who left last year to become president of Tsukuba University in his native Japan (see *PHYSICS TODAY*, October 1992, page 111); John Cocke, the main creator of reduced instruction set computing, the foundation for most of today's workstation technology, who retired last year with health problems; and Leroy Chang, a native of China who worked with Esaki on superlattices and quantum wells, who became dean of science at the University of Science and Technology, Hong Kong.

Leaving IBM does not necessarily mean a complete severance of ties, let it be said. Many researchers are given a kind of emeritus status, assuring the company continued access to their expertise, and their continued



access to the company's computer, laboratory and library facilities.

### A factor of two?

Of course a lot of scientists also are hanging in there, and the more one knows about a particular subfield of condensed matter physics, optoelectronics or computing, the more likely one is to find some very eminent people still working away happily at IBM.

Famous scientists continuing to do research at IBM include Fellow Richard G. Brewer at Almaden, who is known primarily for studies of spin-echo phenomena in optical regimes, and—at Yorktown Heights—Fellows Robert Dennard, principal inventor of the dynamic random-access memory, Rolf Landauer, the condensed matter theorist and information theorist, and Peter Sorokin, the main inventor of the dye laser (as well as the second and third working lasers—that is, the first four-level and rare-earth lasers).

Some scientists known in recent years mainly as research managers and policy experts have left: John Armstrong, until recently the IBM corporate vice president for science and technology, retired this winter; Fellow Ralph Gomory and Lewis Branscomb left well before that—the former for the Sloan Foundation and the latter for the Kennedy School of Government at Harvard. But some important physics leaders also are still there: Paul Horn, the head of the silicon department at Yorktown Heights, Fellow Dean Eastman, the Research Division vice president for physical sciences and technology, and Praveen Chaudhari, formerly a director of physical sciences and a Research Division vice president for science.

Since returning to the Research Division in 1990, Chaudhari has been devoting his time to research, lecturing and serving on IBM national and international committees. But in recent weeks, he told *PHYSICS TODAY*, he also has been spending time writing letters or providing oral statements of recommendation—sometimes two or three per day—for people wanting to take advantage of the RTO for various reasons, including financial ones.

Comparing the situation just down the road to the situation prevailing in the mid-1980s when he was head of physical science at IBM—admittedly an anomalous time, in that several industrial labs were doing a lot of hiring—Chaudhari said the physics staff at Yorktown Heights might end up smaller “by a factor of two.” He added, lest the impression be misleading, that the reduction would result



James C. McGroddy

both from people leaving and from individuals being reassigned.

### Human and national factors

Among those who have left or are leaving IBM Research, the tendency has been to describe Research's situation as “free-fall” and the human element as a tragedy. “For the outsider looking at friends jumping off a burning ship into a ravine, there's no relief,” commented one, a former colleague of Esaki who had just returned from seeing IBM people at the March meeting of the American Physical Society. Noting that those most likely to take the RTO are the elderly or middle-aged, he predicted that such individuals will not find new work doing physics after leaving IBM.

That may be an unduly pessimistic assessment, considering the achievements and qualifications of IBM researchers entering the job market. Certainly it does not take into account the benefits that will accrue to those institutions that have the good fortune to pick up IBM veterans. (One such institution is the publisher of this magazine, the American Institute of Physics, which has just hired IBM's Marc H. Brodsky to be its new executive director—see story below, page 79.)

But from the perspective of the physics labor market as a whole, and even after discounting for negative bias, there is no way to see the developments at IBM Research as good news. Recruitment in physics by IBM already has been at a virtual standstill for several years, scientists trying to leave now face a very tough market, and for every mature researcher who has the good luck to secure a full professorship at a good university, two or three postdocs are likely to find themselves waiting an-

other two or three years for a potentially permanent job to turn up. (Given the tight employment market, some people see getting a job as a zero-sum game—see *PHYSICS TODAY*, May 1993, page 57.)

The same former IBM physicist who expressed sadness about the plight of his peers jumping ship also noted that he now has a postdoc at his university doing a fifth year. One of the most eminent physicists at IBM (and one of those planning to stay) said of a younger collaborator that after doing many years of excellent work the guy now was being required to do “software slavery.”

Independently of personal hardships, IBM's situation also is not good news for physics and for the nation as a whole. IBM Research—like AT&T Bell Labs, to which it inevitably is compared—routinely is described as a national treasure. And yet there has been surprisingly little discussion at the national level of the future of the IBM research laboratories, observed John Poate, a research department head at AT&T Bell Labs. Poate feels this is ironic, given the level of concern about trends in US industrial and academic research and about US competitiveness.

### Product-relevant research

“If you walk into work feeling it's a lost cause, it's a lost cause, but if you have a positive feeling you can do anything,” said Don Eigler, a surface scientist at Almaden who manipulates atoms using scanning tunneling microscopy at low temperatures. Eigler, warning explicitly of the difficulties attendant to presenting a balanced picture of what is going on at IBM, made it clear that he is one of the people thinking positively—and that he has a lot of colleagues in basic research who also are not pessimistic.

James McGroddy, named IBM's corporate vice president for science and technology at the beginning of March, has given talks to research staff in which he has said that funding for what he calls “disconnected research”—basic research not related to IBM's products—would be restricted to 3% of total research spending. A physicist who has worked both in Research at Yorktown Heights and in R&D with manufacturing divisions, McGroddy has a position now that combines his previous job as research director with the vice presidency previously held by Armstrong.

McGroddy has made it clear that he generally will expect researchers to be doing company-relevant research. He told *PHYSICS TODAY* that he especially would not tolerate work that is



neither outstanding in its own right nor helpful to IBM. The emergent IBM Research "isn't attractive, and shouldn't be, to somebody who just wants to work in a tower and only talk to peers in the same field," he said. "Physical scientists have been less adventuresome than we would like in moving into nontraditional areas."

"Over the longer periods of time," McGroddy said, "even the best science has been driven by the problems of the world, not by people who are isolated in the laboratories on the top of a hill." McGroddy made it pretty clear what kind of physics research at IBM he particularly treasures.

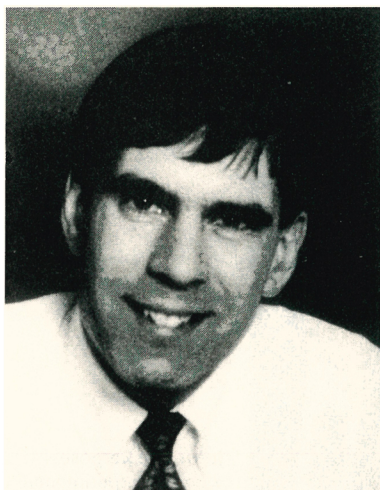
He mentioned a researcher, Webster Howard, who had been working in two-dimensional electron gases and who now works mainly on flat-panel displays, spending a lot of time in Japan. He mentioned a spin glass theorist, Scott Kirkpatrick, who co-invented simulated annealing, yielding nice solutions to the problem of achieving high chip densities in modules. He mentioned the surface scientist John Boland, who has used scanning tunneling microscopy to study how the structure of amorphous silicon for active displays is affected by deposition conditions. Generally McGroddy spoke favorably of physicists leaving basic research for applied.

McGroddy also noted that when work in III-V semiconductors was downgraded because of unexpectedly rapid progress in silicon, and when Esaki left for Tsukuba and Tom Kuech for the University of Wisconsin, "we didn't backfill in those areas." (The Advanced Gallium Arsenide Technology Laboratory was abolished a couple of years ago.)

### Gradients and interfaces

As an example of a researcher he would especially like to keep, McGroddy singled out for praise the work of Bernard S. Meyerson, the most recent IBM researcher to be named a fellow. Meyerson produced Si-GeSi heterostructures used in bipolar transistors that have set world speed records for silicon, matching the performance of most III-V devices. According to McGroddy, Meyerson showed that epitaxial growth in chemical vapor deposition, which everybody thought had to be done at very high temperatures where diffusion tends to take place at interfaces, could be done at temperatures reduced by as much as 400 degrees and that one could get germanium-silicon alloys on silicon with "extremely sharp gradient structures."

McGroddy, who notes that he does



Trey Smith

not like the term "technology transfer," said it has long been his transcendent objective to "blur the interfaces" between basic and applied research and R&D at IBM. Chaudhari credits him especially with having inspired the notion of joint programs—technical programs whose goals are jointly agreed upon by Research, R&D and by manufacturing—during the period Gomory was head of research. "Over the last ten years a large number of joint programs have come into existence, and these have served IBM very well," Chaudhari said. "In a few recent cases, however, where the Research Division had not fully anticipated diminishing demand for a technology or a product, there have been problems."

This was true for example of research connected with the development of bipolar transistors at East Fishkill, New York, and of research related to chip packaging. Both efforts were related to IBM's stubborn insistence on concentrating R&D in mainframes, a traditional mainstay of the company's business, even as PCs and workstations were squeezing the market at one end and supercomputers at the other.

The idea, which may have been misguided, was that the company needed to concentrate on development of high-speed but power-hungry bipolar transistors for mainframe logics, and that these would be put on relatively low-density chips, which in turn would be linked together in glass-ceramic modules. The result, in some minds at least, was that IBM was slow to incorporate high-density, low-power complementary metal oxide silicon technology in logic chips. That in turn, the argument goes, was partly responsible for IBM's losing a potentially commanding lead in re-

duced instruction set computing, which uses CMOS chips.

Moreover, the decision to build a hugely expensive synchrotron radiation ring for x-ray lithography at East Fishkill, an effort in which Research has been heavily involved, also has turned out to be premature at best. The machine is working and is being used for research, and Horn expressed confidence it eventually will be used to manufacture products, but he also concedes that there are no current plans to use it for any specific product in the immediate future. The anticipated applications have been short-circuited by the advent of optical phase-shifting-mask lithography.

The fact that IBM got itself into some trouble both for putting too much money into continued development of bipolar transistors and for making premature investments in an alternative x-ray lithography for low-power, high-density CMOS, shows just how difficult the choices facing the company have been, as one departing researcher observes.

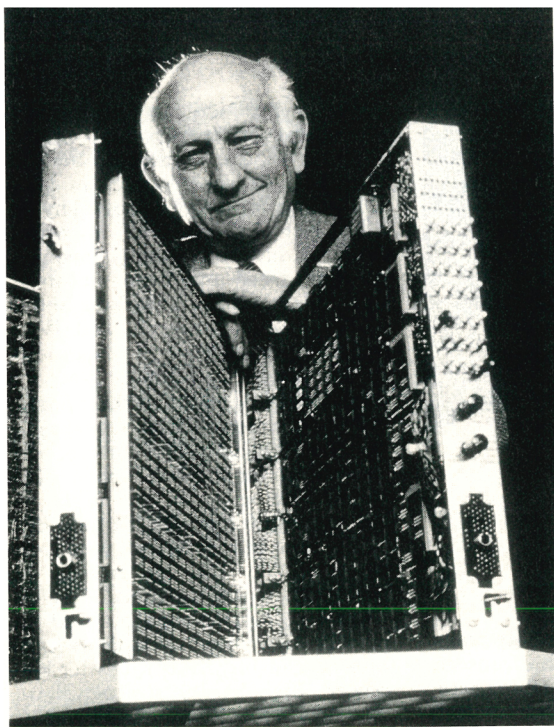
Despite such conundrums and despite the hard adjustments facing the company now, Chaudhari expresses confidence that Research "will come out leaner and meaner." He said he is sure that "management's intent is to preserve a functioning lab."

### The big picture

Two years ago, when PHYSICS TODAY surveyed the situation at AT&T Bell Labs eight years after the court-ordered breakup of the national telephone system (June 1991, page 97), it was not hard to find disgruntled staffers and former staffers who spoke of "catastrophe" and the imminent demise of research, or at least basic research, at AT&T. With the company doing brilliantly in the stock market, such statements could not be taken at face value, and it did not take long to find people who could explain convincingly that the labs were just going through a fine-tuning to adapt to a more competitive environment. But with IBM the fundamentals are different. The company's very survival has been called into question, as the new chairman, Louis V. Gerstner Jr, explicitly conceded in a meeting with shareholders on 26 April. If IBM does not survive, then IBM Research is not likely to survive either. And so in the case of IBM one cannot dismiss the naysayers quite so quickly.

In a book that has just appeared carrying the ominous title, *Computer Wars: How the West Can Win in a Post-IBM World* (Random House, 1993), Charles H. Ferguson and Charles R. Morris present a bleak





**John Cocke** poses with the experimental 801 Minicomputer, which represented the first embodiment of his ideas for reduced instruction set computing.

diagnosis and prognosis: "In 1976, an IBM senior staff planning exercise forecast that personal systems would be a \$100-billion market in 1991, which is close to being right; and they concluded that if IBM could control half of that market, it would be a \$100-billion company now. The market evolved almost exactly as forecast—in fact, IBM made it happen—but instead of owning half of it, IBM's share is only about 15 percent of hardware sales and much less than 10 percent of the total."

Furthermore, they continue, "the [mainframe] 370's hold on the high-performance computer market is slipping; a complete rout over the rest of the decade is not implausible. IBM's minicomputer position is fragile. In workstations, it is in the middle of a very fast pack."

What happened? In 1983, when the US government dropped its decades-long antitrust action against IBM in conjunction with the AT&T divestiture, the underlying reasoning was that IBM and the reorganized AT&T would become direct competitors in telecommunications and computing, which were seen as fast converging fields. The conventional wisdom was that Big Blue, arguably the most successful company in history, had won and that the idea of setting up as a competitor AT&T—which had languished for decades in the comfortable world of a protected monopoly with no free-market experience—was a cruel joke. Eight years later, AT&T has emerged as one of the most successful private enterprises in the

world, and IBM is on the ropes.

One reason commonly mentioned is the antitrust action itself, "a devouring monster," Ferguson and Morris call it, which got IBM in the bad habit of scrutinizing every decision for "how it might play in a hostile courtroom."

A series of major tactical errors during the 1980s in PCs, workstations and software—most notably the attempt to build and market a nonclonable PC and operating system and the near-suicidal alliance in software with Microsoft—already are the stuff of business legend. Strategically, IBM management was overly sanguine about the future of mainframes and failed to anticipate the growing importance of distributed computing.

And then too, perhaps, there was the ambiguous legacy of the founder Thomas J. Watson and his son, T. J. Watson Jr, which may have got corporate managers in the dangerous habit of assuming the company always would be led by a genius. It was the elder Watson who recognized what the punchcard would bring about and who had the inspiration to put all his salesmen in banker-like blue suits and white shirts. (One of the first things Emanuel Piore did when he joined IBM in 1956 as its first full-fledged research director, he claims in a memoir, was to get rid of timeclocks and tell his researchers to dress as they pleased. See *Science and Academic Life in Transition*, edited by Eli Ginzberg, Transaction Publishers, 1990.)

When the younger Watson took

over, according to Ferguson and Morris, he increased R&D spending, which constituted about 15% of net income in the 1940s, to 35% in the 1950s and 50% in the 1960s, setting the stage for the hugely successful 360 mainframe project. "Tom [Junior] didn't need to prove that he was always right, like some other chief executive officers," Piore remembers rhapsodically.

It is easy to find researchers today, especially at Almaden or in retirement, who feel that the Research Division's management got too relaxed in the 1980s, that the best people no longer were promoted to the top jobs in research management, and that Research no longer represented its long-term interests and the company's interests adequately to the corporate leadership.

One such disenchanted person, who has just left Almaden, characterized the syndrome that allegedly set in at Yorktown Heights as "groupthink"—an atmosphere in which research leaders increasingly told their bosses what they thought their bosses wanted to hear. "Those who made the mistakes got more power, those who were right got squeezed out," he said.

McGroddy characterizes that view as "incredible." "In areas ranging across telecommunications, RISC technology, databases, chip packaging, parallel processing, display technology and the physics of radiation effects on our products," McGroddy claims, "Research took positions that were initially contrary to the rest of the company but later succeeded in changing the course of IBM."

### Answering the critics

Critics of the situation at Yorktown Heights in the 1980s rarely are specific about who they have in mind; they seem to blame the entire research leadership.

Naturally current research leaders react with indignation to the charge that their predecessors were inadequate advocates and the implication that they might suffer the same defect. Trey Smith, the newly named director of physical sciences at Yorktown Heights, describes McGroddy as a very strong advocate. Smith attaches little significance to the fact that the physical sciences have been slightly downgraded in that he now reports to Eastman rather than directly to McGroddy.

Eastman, whose job corresponds roughly to that of William Brinkman at AT&T, also has responsibility for silicon, optoelectronics and advanced devices; Smith's responsibilities for basic physics research closely parallel



those of AT&T's Horst Stormer.

Bell Labs and IBM Research have been restructured in strikingly similar ways, in that both organizations have been downgrading work in basic physics, materials and devices and upgrading software, applications and services. This suggests that both are reacting to fundamental forces and are having to take measures that are not merely the result of tactical mistakes or managerial foibles. Yet at the same time, the adjustments and cuts are going much deeper at IBM, and the much heralded convergence between the two companies has yet to appear.

"To first approximation, Bell is [still] photons and IBM is [still] electrons," comments Emilio Mendez, who leads a group working on quantum optoelectronic phenomena in Smith's department (see the article by Mendez and G  rald Bastard on page 34).

### Alliances and other strengths

IBM sometimes is faulted for having had a short attention span and for deserting science that its own researchers have pioneered. Yet even IBM's harshest critics concede IBM Research never could have afforded to pursue every promising lead it unearthed.

In superconductivity, IBM will continue to play a leading role in a research consortium with AT&T and MIT. It is the leader in the effort with Siemens to develop the 64-megabit DRAM and with Siemens and Toshiba to develop the 256-megabit DRAM. Randy Isaacs, a veteran of the Yorktown Heights semiconductor science and technology department, heads up the Siemens-Toshiba project in DRAMs, where IBM still is the world leader.

IBM also has an important alliance with Toshiba in liquid crystal displays, an alliance which—according to Chaudhari—McGroddy engineered. Combining Toshiba's manufacturing skills with IBM's research strengths, the alliance has helped IBM build a surprisingly strong position in laptops.

Other significant alliances include one with GE, AT&T and Honeywell in high-speed optical communications; the Taligent project with Apple and the PowerPC project with Apple and Motorola; and a project on new etching technologies with Lam Research, which Smith has worked on.

IBM remains the world leader in hard drives, developed largely at Almaden, which also has produced heretofore unmatched magnetoresistive head technology. Generally Almaden has specialized in drives, software for

databases and polymer sciences. Its Center for Computational Chemistry, a vehicle for selling hardware to the petroleum and chemical industries, is something that the company will build up. Its group in basic physical sciences, though, always has been small, and the physicists still there seem to be the ones most worried that IBM's efforts in basic physics may fall below a certain critical mass and be discontinued altogether.

### The long look

Seen in the very broadest perspective, IBM may fairly be said to have been an almost inevitable victim of its own successes. In particular, Dennard's invention of the basic DRAM memory cell, consisting of a transistor and capacitor, so revolutionized the cost of memory, Cocke observes, that "nothing we had been making was competitive with the technology we were

developing."

"IBM did well to stay as good as it was for as long as it did," Cocke continues, "and so you can't say management did a dreadful job." While he was one of a group that saw what was coming in workstations and distributed computing, "they [management] had a goose that was laying golden eggs, and so it was hard to get on with things that competed."

Cocke agrees that IBM probably was due—irrespective of tactical and strategic errors and managerial lapses—to take a pounding, no matter what. What remains to be seen is whether the new generation of research managers and corporate leaders will have the foresight to continue pioneering and to stay with the basic sciences and technologies that will be decisive in the next century.

—WILLIAM SWEET

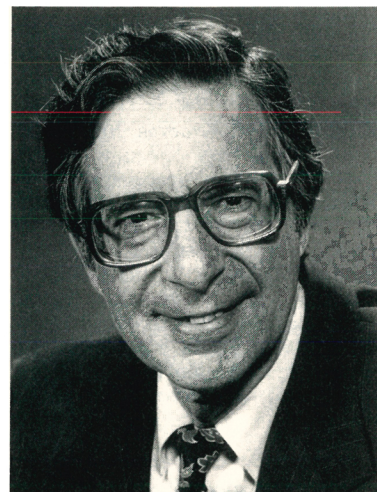
## IBM'S BRODSKY WILL SUCCEED FORD AS NEXT EXECUTIVE DIRECTOR OF AIP

Marc H. Brodsky, a physicist at the IBM Thomas J. Watson Research Center in Yorktown Heights, New York, has been named new executive director and CEO of the American Institute of Physics. On 1 November he will succeed Kenneth W. Ford, who is retiring after seven years at AIP's helm.

Brodsky's taking office will coincide with the move of AIP headquarters to College Park, Maryland, where a building for the newly created American Center for Physics is under construction. The center will provide a new home for AIP, the American Physical Society, the American Association of Physics Teachers—which already is based in College Park—and the American Association of Physicists in Medicine (see page 80).

Brodsky, who earned his undergraduate and doctoral degrees in physics at the University of Pennsylvania, joined IBM in 1968. For most of his career there he worked primarily as a researcher; he became a research department manager in 1980 and later a top-level Research Division executive. During the research phase of his career he studied amorphous semiconductors, identifying defects that dominated their optical and electrical properties, especially those associated with dangling bonds.

Brodsky has had a strong personal and professional interest in education. He has served on the American Physical Society's education commit-



Marc H. Brodsky

tee and on local school and library boards.

### Research highlights

Working with the late Reuben S. Title in the late 1960s and early 1970s, Brodsky identified the electron spin resonance signal from dangling bonds. He did a series of studies with groups of colleagues that correlated defects with excess optical absorption, extrinsic conductivity and density deficiencies. He then performed many experiments that quantified and characterized hydrogen in amorphous silicon.

From 1973 to 1980 Brodsky was