Special Report



MARK PENBERTHY

CAN AMERICA COMPETE?

ITS OPTIONS ARE A SURGE IN PRODUCTIVITY—OR A LASTING DECLINE

Take this statistical portrait of a 45-year-old worker, adjust it for age and sex, and see if you can relate. There are millions like him, and his story says a lot about what is happening to the U. S. and why its economy is so troubled.

When he started working in the 1960s, our worker's income was climbing more than 4% a year. After inflation, his hourly wages rose close to 2% a year. Real raises came easily, because the economy was booming and productivity gains were consistently strong. The U. S. was virtually unchallenged as industrial leader. Americans could make anything, and because their products were the best, they could sell whatever they made, both at home and abroad.

But somewhere around 1973, the gravy train was derailed—and it has never really gotten back on track. It may have been a combination of things: Vietnam, the OPEC price shock, the inflation spiral. U. S. producers met fierce competition from foreign industries that churned out high-quality goods made by low-wage workers. And, the experts now say, the great wave of innovation that began after World War II peaked.

Whatever the causes, productivity sagged. The U. S. economy grew more slowly. Our typical worker's raises soared to 7%, but it was all inflation. In real terms he took a pay cut. By the end of 1986 his real wages were back to their 1969 level.

Another funny thing happened in the 1970s. Perhaps it was what economists call "money illusion," but our worker kept spending as if he were still getting the kind of real raises that he won in the 1960s. His thinking was "buy now, before the price goes up again." With a little luck, he figured, his next raise would keep the credit-card bills and the mortgage covered.

But the real raises didn't get any better in the 1980s. Our worker heard horror stories about declining U. S. productivity and competitiveness, givebacks, and widespread layoffs in manufacturing. But he couldn't lower his sights, so he started borrowing. He now owns a house, a big Japanese color TV and VCR, an American car, and a Korean personal computer—all bought on credit. He is making ends meet, but only because his wife went back to work two years ago. Her income covers the children's orthodontist bills and family entertainment, but it falls short of what they'll need to send the kids to college. He feels as though he's on a treadmill. One of these days, he keeps saying, he and his family have got to tighten their belts.

This, in microcosm, is what has happened to the U. S. over the past two decades. The nation is in a growth crisis, the kind that sneaks up on people so that it takes months or even years before they know what's hit them. Long-term growth has slowed to a crawl, and without a rapidly growing economic pie, America just isn't the same. Both personal and national agendas that were once unquestioned suddenly seem too expensive. For individuals, that might mean a delay in buying a home or even getting married. For the nation, the list includes the programs that burgeoned in the 1960s and 1970s to care for the poor and the elderly, the projection of U. S. power overseas, and the pushes for safer workplaces and a cleaner environment. Which do we give up?

The U. S. has not stopped growing. But the decades of breakneck expansion after World War II conditioned Americans to expect more from their economy, and the slowdown has opened a huge chasm between expectations and reality. In the 1950s and 1960s, real gross national product rose by 4% or more in 11 years, and that 4% came to be considered the norm. Real GNP growth averaged 3.8% in the 1960s (chart, page 46), and the nation spent right up to its income. When growth slid to 2.8% in the 1970s, that barely fazed Americans. They simply made up the difference by borrowing—at first from each other and then, increasingly, from over-

INTRODUCTION
Our competitive drop is really a growth crisis. It must be fought throughout the economy—starting in the factory

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JAVIER ROMERO

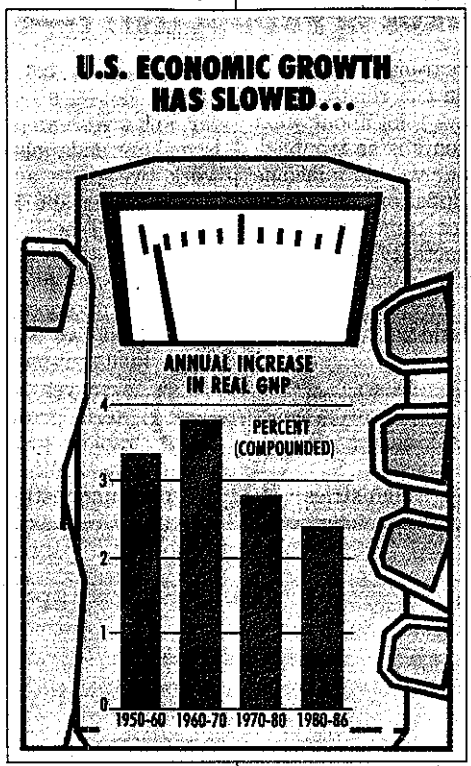
seas. Since 1980 growth has averaged only 2.4%. Spending has grown so much faster, especially for imports, that by 1986 the U. S. was consuming almost $150 billion more a year than it produced (chart, page 47).

As a result, the ratio of personal debt to income is now 30% above normal for this stage of an expansion, according to economist John H. Makin of the American Enterprise Institute, and the national debt exceeds $2 trillion. Even more worrisome, the U. S. has become a debtor nation on a scale undreamed of by any developing country. U. S. debt to foreigners could exceed $750 billion by 1990 even if the trade deficit starts to shrink this year. And, says Makin, "all this debt reflects America's failed expectations for growth."

One way or another, if slow growth is not reversed, Americans will become poorer and their standard of living will sink. By some measures it's already happening (page 48). Burton Zwick and Susan Lakatos of Kidder, Peabody & Co. figure that the U. S. must fork over 1% of GNP a year to foreigners for the next five years just to service this debt. In effect, says Paul R. Krugman of Massachusetts Institute of Technology, "the U. S. will have to give back all of the standard-of-living increases we've borrowed from foreiguers."

To put this another way, servicing foreign debt will consume about one percentage point a year of U. S. production. If output grows only by 2.5%, Americans will be left with just a 1.5% gain for themselves. To make up the difference, they will have to consume less.

This is the inexorable arithmetic of the balance-of-payments account. Ultimately foreigners will want to be paid back, chiefly in goods. To meet this demand, U. S. manufacturing must revive and rebuild its share of world trade. Services are simply too small a part of U. S. exports to push the trade balance into surplus. If U. S. producers can't compete on quality and productivity (page 54), the currency markets will keep knocking the dollar down until American wares are cheap enough to market overseas. The resultant inflation would reduce real wages and profits further. If foreigners sharply curtail their lending, interest rates would then soar, and the next stop would be recession.



RUNAWAY DRAIN. Obviously, trade is a critical element of U. S. growth, although economics textbooks never made much fuss about it until recently, considering it a marginal part of total production. Today, exports and imports together amount to 24% of real GNP, compared with 16% in 1970. The 1986 trade deficit, $170 billion, equaled 4% of GNP—roughly the excess of U. S. consumption over production.

Of course, foreign creditors don't have to take U. S. goods in payment: They can buy America instead. With the dollar declining, U. S. assets, both real estate and corporate, become a bargain, and the cash-rich Japanese and other foreigners already are seizing the chance to invest here. Foreign investment should spur U. S. output and save American jobs. But the nation still could lose, since a growing portion of U. S. income must wind up overseas.

Is there any alternative? Yes: Grow faster. Says Nobel laureate Lawrence R. Klein of the University of Pennsylvania: "If we got our priorities reoriented, the U. S. could achieve a growth rate of 3% to 4%. That's what we should be aiming for." But some economists are skeptical: "It's whistling in the dark to think we can grow our way out of this," says Krugman. "Raising real growth is a very long-term proposition."

When it comes to growth, many economists start to sound like old-time Calvinists discussing predestination. The sinning economy may outrun its destiny for a while—and many forecasters think that a turnaround in the trade deficit will boost growth to 3% or so this year. But no amount of good acts in the near term will guarantee a lasting improvement. Economic growth is simply the sum of the growth rates of the labor force and productivity. Unless the U. S. eases its restrictions on immigration, which it may have to do by the end of this century, labor-force growth is a given, and it's settling down near 1.5% a year. Productivity growth seems to be stuck around 1%. Add these numbers, says Charles F. Stone of the Urban Institute, and "that upper limit of 2.5% doesn't change."

But is 2.5% growth really predestined? Not if the U. S. starts to compete again. That would require a strong, sustained surge in productivity—and there are no quick fixes. Americans would have to work harder and manage smarter, especially in manufacturing. Service industries would have to figure out why their productivity is still feeble after two decades of computerization. Washington must realign its economic policies to foster saving and investment instead of runaway consumption. And, most important, U. S. business and labor need the flexibility to operate in a rapidly changing world economy where the newest technology and trillions of dollars flow across borders almost at the speed of light.

Watch out for "flexibility." It may soon be a hotter buzzword than "competitiveness" is today. In a sense, many of the actions taken by business and Washington since the early 1970s can now be seen as ad hoc attempts to achieve economic flexibility and position U. S. industry to respond to foreign competition. Whether each made sense is arguable, but all were driven by the need to keep American companies in the game. Here are some of the recent moves in this direction:

- Deregulation was aimed at freeing business from excessive government intervention. It's working.
- Product diversification strove at keeping up with swift changes in markets, but it was a flop for many companies.
- The development of the service-oriented "hollow corporation" (BW—Mar. 3, 1986) is a strategy to escape high U. S. wages and rigid work rules by buying most components and entire products overseas. It may maximize profits in the short run, but it can cost companies and the country the ability to manufacture and innovate.
- Corporate restructuring—the razzle-dazzle game of mergers, acquisitions, and leveraged buyouts—has attacked the hierarchical rigidity of some old-line, mass-production companies that resisted change. Many needed shaking up, but it is not clear whether the benefits have been worth the carnage.
- The rise of high-tech entrepreneurs recalls the freewheeling, frontier-breaking style of the 19th century (page 64). Overall, it has been worth every dollar of venture capital spent.

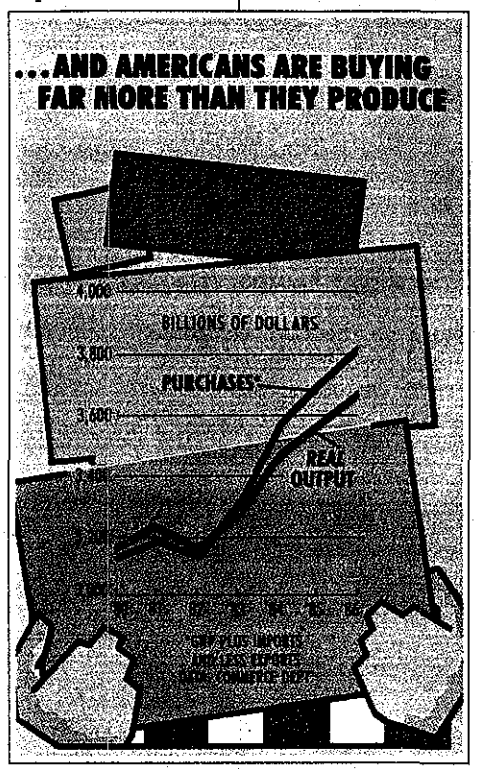
Each of these approaches has its positive side. But collec-

CHARTS BY ROGER GORMAN

tively they miss the mark. To the extent that such strategies have relied on reducing real U. S. wages, eliminating or downgrading jobs, and simply propping up short-term profits, they defeat the major purpose of competitiveness: to be able to sell a country's wares at prices that give its investors a fair return and its population a rising standard of living.

The burden rests largely on U. S. industry. John Zysman, a political scientist at the University of California at Berkeley, warns that companies that "become expert at making or marketing cheap-labor goods will lose their technological edge sooner or later and wind up making nothing but low-value-added goods." Adds Stephen S. Cohen, co-author with Zysman of the forthcoming *Manufacturing Matters: The Myth of the Post-Industrial Economy*: "The U. S. and its companies must keep their mastery over manufacturing. You can't control what you can't produce."

HARD CHOICES. Cohen and Zysman argue that in a world of open markets, rapid technology transfer, and ever-shortening product life cycles, full competitiveness requires a lot more flexibility than shuffling financial assets or moving jobs, production, and technology overseas can achieve (page 56). Companies and their stockholders must choose between playing the short-term maximization game and making money by investing for growth and appreciation. Industry must step up its tentative moves toward programmable automation and flexible manufacturing systems, techniques that emphasize shorter production runs and response times over economies of scale.



Specifically, flexible manufacturing would let manufacturers customize one product line or shift quickly from product to product with virtually the same equipment. If it works, it should permit makers of specialized high-value products to match the cost-efficiency of mass production. It departs sharply from conventional commodity production and assembly-line techniques that permit little variability in the product.

Skeptics argue that a major move toward flexible manufacturing would turn the U. S. into a "boutique economy," too fragmented to be efficient. Proponents reply that flexible production is enabling West Germany and Italy to overtake the U. S. in productivity and capture increasing market shares in such products as machine tools and textiles.

Differences over flexible manufacturing are causing sometimes-bitter debates in U. S. companies, where many executives see it as too radical a departure. Economist Michael J. Piore, who has been studying manufacturing organization in the U. S. and abroad as part of a "Management in the 1990s" project at MIT, notes that "every major American company is examining or even trying new approaches to manufacturing. And labor is working on this, too."

But while many companies are willing to make some big changes, says Piore, "they still want to go only partway. They think they can simply apply the techniques of flexible specialization to mass production."

It is not surprising that many U. S. executives are reluctant to risk a full commitment to flexible manufacturing. The investment is costly, and mistakes can be disastrous. What's more, success requires cooperation with labor and reliance on government to maintain a steady policy environment, and business isn't used to trusting in either. "The overvaluation of the dollar came just when people had to make fundamental changes," says Piore. "It created vast uncertainty about whether business could still build or maintain mass markets. It caused a loss of confidence and direction."

The Reagan Administration's reversal on tax policy has added to business uncertainty. Although last year's Tax Reform Act ultimately should make allocation of capital more efficient, industries that have lost the investment tax credit and other breaks argue that they've also lost an incentive to manufacture in the U. S.

But if capital spending is critical to productivity, it's only part of the story. To foster growth, capital must be deployed efficiently, and that is up to management. In the Reagan era, notes economist Everett M. Ehrlich of the Congressional Budget Office, "we've achieved price stability, shaken down the tax laws, stabilized regulation, and driven down unit labor costs. Yet the economy has been unable to fire a second stage." Ehrlich attributes much of the economy's sluggishness to the huge budget deficit, but beyond that, "it comes down to management."

WASTED BOUNTY. To make capital work well, business also needs an educated, skilled work force that cares about what it's producing. This will become clearer to managers as new production technologies are introduced. Getting the kind of labor force needed to make flexible automation work will require management and unions to abandon the old adversarial attitudes and strive for cooperation (page 61). If unions resist such change, they will guarantee a continuing loss of jobs and production to foreigners. Manufacturers, for their part, can flee the U. S. or make their domestic operations pay better by investing more in training and encouraging worker participation.

Finally, there is the little item that shows up at the end of every economist's productivity equation: technological progress. It is the hardest component of growth to measure, yet no one doubts that it often is the most powerful. The U. S. has never wanted for inventiveness and creativity, yet it has managed in recent years to squander this bounty.

For a while in the 1970s, U. S. business scaled back research and development spending just as it was becoming most critical for meeting foreign competition (page 59). Both federal and private spending on basic research became skimpy. For want of capital, inventors and high-tech startups sold their richest ideas to foreigners before they could flourish as innovative new industries in the U. S. Manufacturers repeatedly failed to move from the R&D stage to full production. Strategic alliances between U. S. and foreigu producers often wound up with the American producers giving their technology away (page 62). Such miscues put the U. S. behind in fiber optics, for example, and kept it out of VCRs entirely.

Getting more Americans to realize that it pays to make things in the U. S. is the heart of the competitiveness issue. This is no small order. But the task can start with a hard look at the sources of U. S. growth, its prospects, and the cost of letting it languish.

By Norman Jonas in New York

WARNING: THE STANDARD OF LIVING IS SLIPPING

Adjusted for inflation, paychecks are declining for many people

Is the American dream about to end? For the first time since the Depression, millions of Americans face the growing likelihood that they will not be able to live as well as their parents. Caught in a vise between slowing productivity and fierce competition from low-wage foreign producers, many workers are being forced to accept pay cuts to save their jobs. Manufacturing continues to decline as a source of high-paying jobs, while services boom. But the service jobs offer mobility only to a well-educated top tier of the work force.

Other workers who might have gone into the same plant that employed their fathers find those jobs disappearing. And they may lack the education and skills needed on Wall Street or Route 128. Corporate restructuring, too, is driving hoards of middle managers and white-collar workers onto unemployment lines or into lower-paying jobs.

What's happening is painfully simple: The U.S. standard of living, long the envy of the rest of the world, has hit the wall. In fact, there is overwhelming evidence it's already slipping for many people and may drop even more unless the U.S. can reverse its productivity decline of the last 15 years or so. Says former Labor Dept. Under Secretary Malcolm R. Lovell Jr., who now teaches at George Washington University: "The standard of living hasn't been going anywhere for a decade." For nonsupervisory workers—some four-fifths of the work force—wages adjusted for inflation have fallen since their peak in 1972.

THE SWEAT FACTOR. If cooling off the growth of wages is the only current way to keep the U.S. competitive—at least until business can make itself more efficient in other ways—what's so bad about it? After all, says Richard S. Belous, an economist at the Conference Board, "we still have a tremendously stable society, and the proletariat isn't about to storm Bloomingdale's."

Right, but Belous raises some more serious issues: "If we don't start growing again, a dropping standard of living will bring more inequality and could cut off some of the traditional roads to advancement." That could shake the nation's governability, he adds, by "making it harder for politicians to form broad, lasting coalitions." For business, it could mean a resurgence of unionization, even among professionals, and a further erosion of worker loyalty.

The standard of living is a difficult concept to define, much less measure. To see how the average person has fared, some economists take the real gross domestic product—the total output of goods and services in the country—and divide it by the population. That yardstick shows that GNP per person increased at a brisk annual pace of 2.6% a year from 1960 to 1970. But since then



ROGER GORMAN

the rate has fallen to a 1.6% annual rate (chart). Other economists prefer to look at what has happened to the income of the typical household. And that tells a more dismal story. In 1973, median household income, after adjusting for the effects of inflation, was actually almost 8% higher than it was in 1985.

The stagnation in income is even more disturbing because more people than ever are working to produce that same income. What economists call the sweat factor has risen. The number of people employed has jumped from 40% of the population in 1970 to 46% today, as the baby boom has swelled the number of working-age people and more women have gone to work. The overall labor force has grown by nearly 28% since 1973, to more than 115 million, and two-thirds of the 33 million new workers are women, who now account for 44% of all employees. Since hourly wages in real terms have fallen 8.7% since 1973, it is these added workers who have helped families keep their heads above water.

NO HONEYMOON. Look at what would have happened to living standards if men had remained the sole breadwinners. According to a study last year by the Joint Economic Committee of Congress, a 30-year-old male earned—in 1986 dollars—an average of $25,253 in 1973. Ten years later, the average 30-year-old man earned only $18,763 after adjustment for inflation—one-fourth less. "Clearly, if only the father worked in an average young two-parent family in the 1980s, there would be a drastic decline in family income as compared to 1973," states the Committee's report. Even with more wives working, the report finds that the average income of two-parent families fell by 3.1% from 1973 to 1984. The decline would have been three times as large if more mothers had not gone to work.

The conclusion is unsettling: Many American families now must put two people to work to match the living standard that one person could have provided in previous decades. Some economists argue that many women are working not out of necessity but because they want to. Nonetheless, their extra income should make their families better off. Instead, the average family is working harder just to stand still. "Today, you need two people working to make what is considered a middle-class standard of living," says Frank Levy of the University of Maryland.

To keep spending as their income falls, U.S. families have gone deeper and deeper into debt. Consumer installment debt rose from 13% of personal income in 1973 to more than 16% last year. And that doesn't include all the home-equity loans that are being used to buy cars and other products.

Slow economic growth has had its most dramatic effect on those born during the baby boom. Many baby boomers have delayed marriage, in part because of the sexual revolution but also because of the decline in their ability to earn a decent living. The data show that instead of getting married at 22, as their fathers did 30 year ago, men on average today hold off until they're 26. Women whose mothers married at about 20, now wait until they're 23. When they do marry, these young couples put off having children. And the number they choose to have is down as well: The birth rate has dropped from 24 children per 1,000 women in 1960 to 15 per 1,000 today.

The baby boomers also have had to settle for less in other ways. Many live in smaller houses than those of their parents: Less than half of new housing units today are single-family detached units, compared with more than 60% as late as the 1970s. They also get by with fewer necessities. The typical family headed by someone aged 25 to 34 spent 14% less on furniture in 1981 than a similar family did in 1973, according to a



ALAN LEVENSON

NOW, EVEN THE DAILY PAPER IS A LUXURY

Most Americans today expect at least to match the lifestyle they enjoyed growing up in their parents' house. But Curtis and Cynthia Paltza are finding that modest goal out of reach.

When the couple married two years ago, they planned on a house and children and maybe even a second car. Now they have a seven-month-old daughter, Breanna. But they still live in a rented apartment, though Curtis' office job with the Los Angeles School District pays $27,000 a year—close to the $27,735 median annual family income in the U.S. in 1985. Even buying the daily newspaper has become a luxury the family can no longer afford.

Since Cynthia quit her $10,000-a-year job as a florist to raise Breanna, the comfortable life their parents had has become even more elusive for the Paltzas, both 30. Half the $1,246 a month that Curtis brings home goes for rent. To pick up an extra $30 a month, he monitors college entrance exams at California State University at Long Beach.

Meanwhile, the Paltza's indebtedness keeps climbing. The car recently broke down, swelling their Visa bill to $800. And they still have not repaid the $1,300 they borrowed for the security deposit and the first month's rent on their apartment in the south Los Angeles community of Lomita.

STILL HOPING. Even so, the rough times haven't dampened the Paltzas' hope of finding a home of their own. Somehow they manage to put $55 a month into a savings account. But it will be tough to match what their parents had. Curtis' parents lived nicely on the combined income they earned from his father's job as a produce worker at Safeway Stores Inc. and his mother's job as a secretary. In 1949, when his parents were both 25, they could afford to buy a $7,500 house.

"By comparison to us our parents were self-sufficient," laments Curtis. Adds Cynthia: "It was much easier to make ends meet back then. Our parents feel sorry for young people today—they know how hard it is for us."

Joint Economic Committee study. They spent 15% less on personal care, 38% less on charity, and only $47 more a year on food outside the home, despite the fact that the woman most likely worked. "The young middle class has experienced a dramatic decline in its ability to pursue the conventional American dream: a home, financial security, and education for their children," says Richard C. Michel, an economist at the Urban Institute and an author of the study.

The stagnant economy has hit those at the bottom of the heap hardest. Families without two earners have suffered the most, especially those headed by women. Single women now head 16% of all households vs. 12% in 1973. With a median income of $13,660 a year, many of these households are below the poverty line. Indeed, they have been a big reason why the overall poverty rolls have jumped from 11% to 14% of the population since 1973. The gap between rich and poor is at a postwar high: The poorest one-fifth of the country's households now receive less than 5% of all income, while the wealthiest one-fifth receive more than 40%. "Inequality grows as the standard of living falls," says the Conference Board's Belous. "Since the early 1970s inequality has been increasing, and the trend has become more pronounced in the 1980s."

Even the majority of Americans who have maintained their living standards may not be able to do so much longer. The rush of women into jobs has begun to slow. Baby boomers are reaching the age where children must be borne or put off altogether. And there are limits as well as economic costs to the debt levels the economy can bear. "We can't keep [living above our means] forever, but while we're doing it, it's like having a great party on borrowed money," says Lester C. Thurow of Massachusetts Institute of Technology. "At some point, we're going to have to pay the bill."

TALL ORDER. Most economists agree that a return to fast economic growth is the only long-term way to keep the standard of living from declining further. But even a healthy economy doesn't necessarily mean well-off consumers. Since the recession of the early 1980s, much of Corporate America has been trying to boost productivity. But while productivity has rebounded in many manufacturing industries, the gains often have come from cutting wages, dumping inefficient plants, and exporting jobs overseas. Such measures may help individual companies return to health, but they also slash at overall living standards.

And the new jobs being created by the recovery may not offset this decline. A controversial study by the Joint Economic Committee last year concluded that while some 9 million new jobs were created from 1979 to 1985, 44% of them pay $7,000 a year or less. If it's true and the pattern continues, the U.S. could find itself in a peculiar situation: Companies could begin making record profits and the economy could surge ahead, while incomes decline for the vast reaches of the middle class and for lower classes.

If the economy is to grow in a fashion that augments living standards, companies have a tall order in front of them: They must boost wages and output as well as productivity. This has been the traditional way that economic growth has occurred. But if it doesn't begin to happen again soon, an increasing number of people will find the American dream is just a dream after all.

By Aaron Bernstein in New York



PETER YATES

'I HOPE THINGS WILL BE EASIER IN THE FUTURE'

Ronald W. and Judith P. Bateman face a problem that's all too typical of their generation: How to raise a family on what they earn. Despite the neatly printed ledger pages that detail each dollar of the couple's monthly budget, they laughingly lament their weekly "deficit spending." Without the $4,000 a year in overtime pay that Ronald earns as a dispatcher for Michigan Bell Telephone Co., they figure his $25,000 base income would leave them with a $70 shortfall every month. "We don't have anything in our budget for clothes or car and house repairs," says Judy, 32.

The Batemans, the parents of a six-month-old daughter and a 2½-year-old son, are hardly big spenders. Even their so-called splurges are lessons in frugality. By choosing the right restaurants and doing some savvy meal-sharing, boasts the 27-year-old dispatcher, who helps coordinate telephone installation orders for Michigan Bell, the family manages to eat out once a week for less than $10—tip included.

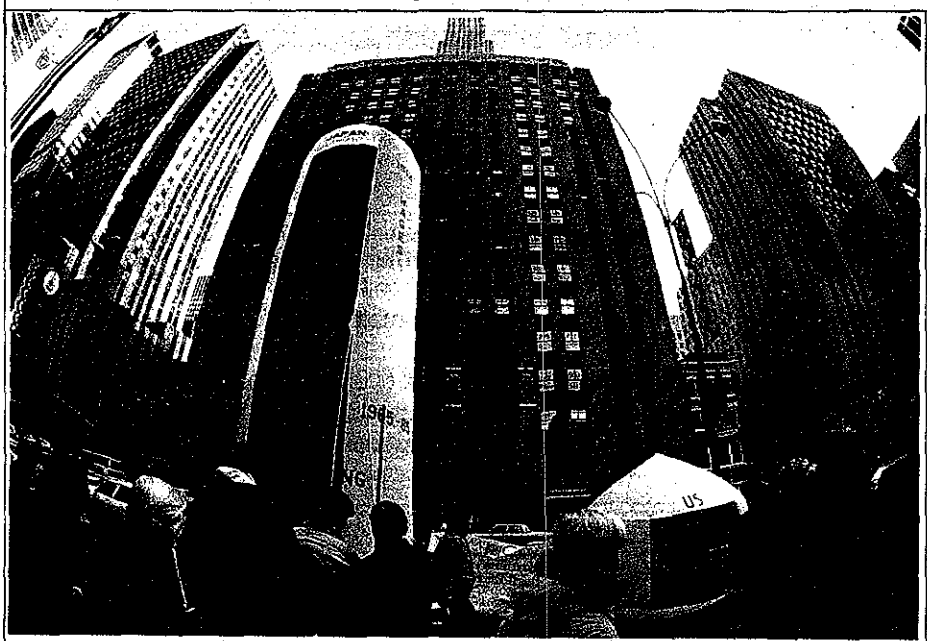
The couple is fortunate in one sense: Cheap housing can still be found in Detroit's suburbs. But their $29,000 home is in a fairly rundown section of Hazel Park. The Batemans managed to save enough for that purchase only by living with one of Judy's brothers for a year. And the couple still had to take a loan from Ronald's parents to complete the downpayment.

STAYING HOME. Last year, Judy added about $2,500 to the family's income by working sporadically as a secretary. The late-night schedule left her little time with her husband, but it spared them baby-sitting expenses. Now she intends to stay home with Erica and Aaron. But without her paychecks, she admits that "we're not going to be able to do the things we wanted to do."

Ronald says his mother worked as a secretary and spent the money on extras. In contrast, Judy's earnings always go toward bills. "I hope things will be easier in the future," says Judy. "I know we're sure working towards it." Until then, she laughs, "we enter a lot of sweepstakes."

PRODUCTIVITY: WHY IT'S THE NO. 1 UNDERACHIEVER

Growth is stalled by an aging capital stock and a poky service sector



A DEMONSTRATION IN NEW YORK POINTS UP JAPAN'S GAINS IN EMPLOYMENT PRODUCTIVITY

KEN KERBS

Although there's no free lunch, one thing comes awfully close: productivity. When it's growing, business can do the impossible. Companies can hand out raises, slash prices, and increase profits—sometimes all at once. Productivity transforms luxuries once reserved for society's elite into ordinary household items. Malthusian prophecies of worldwide starvation and scarcity turn into archaic curiosities. Even warnings that workers won't be able to support the next generation of retirees sound less ominous, if productivity can be counted on.

But for all its potential, productivity has not been living up to its promise lately. Output per worker has been growing, on average, less than 1% a year since 1973, compared with a rate of more than 2% in the 1960s. If the higher rate had been sustained, a worker's output would double in 32 years. At the slower rate it takes more than 70 years. Wages follow productivity almost in lockstep, and the cumulative effect of the shortfall on incomes is huge: "It's as if every worker were leaving $10,000 a year on the table," says Carl G. Thor, senior vice-president of the American Productivity Center in Houston.

Business depends on productivity as much as workers do. Manufacturers in 1986 were able to offset wage inflation and hold unit labor costs flat. For most companies outside of manufacturing, however, productivity was stagnant, and higher wages simply flowed through to higher prices.

THE CULPRIT. The lag in productivity is clearly a culprit in America's declining competitiveness. U. S. trade rivals are scoring faster productivity growth, and America now ranks near the bottom among industrialized countries (chart).

Economists have come up with some reasons for the productivity slump that started in the late 1960s and turned into a rout in the 1970s. The slowdown began with the arrival of the baby boomers in the job market. The flood of young workers dampened the postwar productivity surge by reducing the overall level of experience and skills. Business also had to absorb the shock of soaring energy prices, a tidal wave of government regulation, and accelerating inflation. Managers steered investment almost single-mindedly to projects that conserved energy, not capital or labor. Faced with lower inflation-adjusted rates of return, business cut back on capital spending.

The result is an aging capital stock. The average age of a manufacturing plant was about 15 years at the end of 1986, vs. 13.8 years in 1980. For equipment, the average age is up by half a year.

Yet, the greatest drag on productivity growth has come from the ever-expanding service sector. Many service firms, from far-flung bank holding companies to the boutique on the corner, have been frustrated trying to squeeze more output from less input. Since 1979, output per hour in service-related industries has risen less than half a percent a year.

The official figures may be understated, economists suspect, because the volume of services is difficult to measure. Tons of steel are counted more easily than the output of attorneys. Government statisticians have resorted to plugging in workers' earnings as a proxy for the value of output for 20% of services. "Instead of output, they measure labor input," says John W. Kendrick of George Washington University. "For some industries, they compute zero productivity growth just by definition."

BUYING BINGE. It's more than a measurement problem, however. While factories typically use capital equipment to economize on labor or to increase volume, the same cannot always be said for service firms (nor the white-collar divisions of manufacturers). More than $160 billion invested in high-tech equipment—computers, communications gear, and the like—since 1985 has not produced broad-based savings, reports Morgan Stanley & Co. economist Stephen S. Roach. Data-processing divisions went on buying binges, says Roach, believing that "productivity paybacks would be automatic."

Instead, corporations have mined data more intensively. Management nurtures a "let's-calculate-it" mentality, says economist Lester C. Thurow of Massachusetts Institute of Technology. "Reports we used to do every three months we now demand every day," says Thurow. "Nobody asks if this added knowledge generates new output."

Manufacturers, too, are less able to

demonstrate productivity gains in their offices than their factories. Minicomputer maker Tandem Computers Inc., of Cupertino, Calif., for example, has cut the average design time for its semiconductors to just 4 weeks from 14, after installing several million dollars worth of computer-aided design equipment. But Tandem cannot identify similar savings for its largest white-collar investment, an information network that links marketing, engineering, and manufacturing divisions at 200 locations in 35 countries. Tandem has poured tens of millions into the network, according to Stephen C. Schmidt, vice-president for operations. "We all think it makes us a lot more productive," says Schmidt. "But I'd be damned if I know how to quantify it."

BACK ON TRACK. Basic manufacturing operations, though, have managed an impressive comeback. Forced by foreign competition to slash its labor force and close obsolete plants, the U. S. manufacturing sector has essentially recovered from its 1970s slowdown and is back on a 3% growth track. If not for the sluggishness in services, total U. S. productivity would have grown by a respectable 2.2% since 1979. But the service sector can boast a crop of winners: Communications and rail transportation have turned out sizable productivity gains.

Many economists warn that broader efficiency gains will be hard to come by unless workers have the levels of education and skill required to handle advanced technologies. This means that the U. S. will have to make greater investments in its "human capital." The economy may not be able to abide a 13% illiteracy rate much longer.



Whatever shortcomings the U. S. may have in human and physical capital, the nation has long enjoyed a clear advantage in what experts consider the most important, though least controllable, component of productivity growth: technological progress. It may appear as an unexpected breakthrough, such as the latest discoveries in superconductive materials (BW—Apr. 6), or as incremental follow-up advances. Despite decades of debate, the uneven pace at which technology advances remains a mystery to economists. But most agree that the rate can be influenced by spending on research and development.

Here the U. S. could be doing more to help itself: Outlays by business and government for civilian R&D are a smaller share of the economy in the U. S. than in other countries.

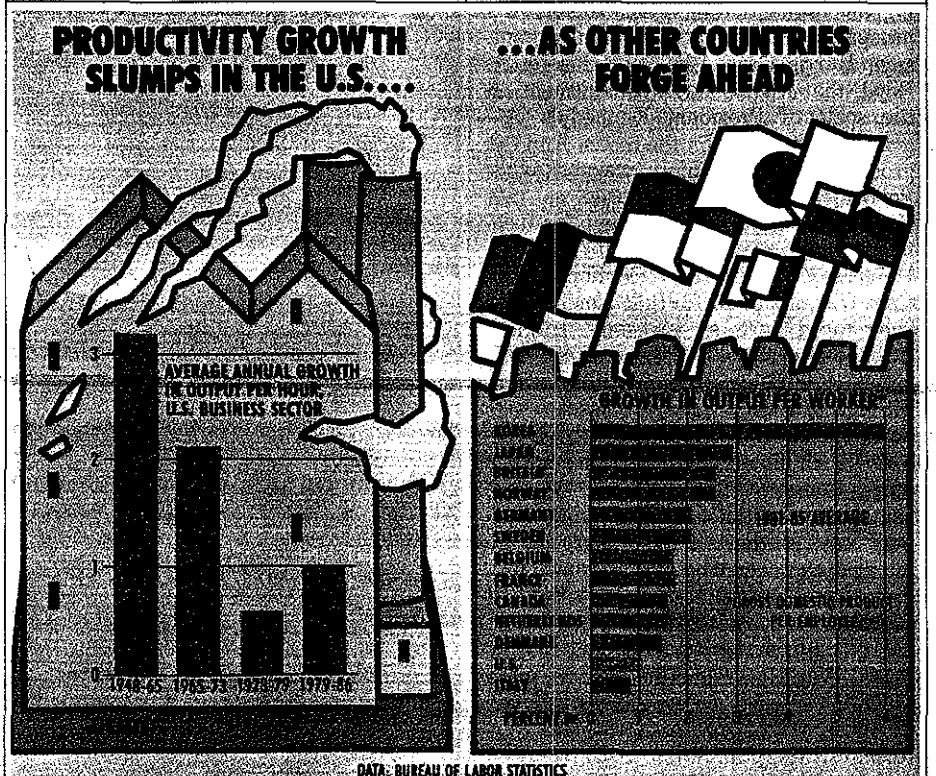
The record of the last 15 years or so gives the U. S. the edge for initial product inventions. But it is Japan that wins the accolades for bringing down costs in the commercialization stage. "In the kind of research that wins Nobel prizes, we've done extraordinarily well," says technology expert Nathan Rosenberg of Stanford University. "But basic science is now an international commodity—you can pick up a lot in other countries just by reading scientific journals."

The next competition: superconductivity. Commercial use of the low-resistance conductors of electricity, though still years away, is likely to provide more conventional cost-cutting and output-expanding technology than computers have. Scientists believe superconductors will help revolutionize operations in service industries, such as transportation, utilities, and even health care.

TURNAROUND TIME. Does it matter which country capitalizes on a new technology first? Absolutely, if the country is running a huge payments deficit with the rest of the world. True, economists expect other countries to adopt U. S. technology and their productivity growth to outpace America's—that's what happens when nations play catch-up with the leader. But they do worry that turning around the massive U. S. trade deficit, which climbed to $170 billion last year, will be much more painful without a productivity revival.

Otherwise, "the exchange rate will bear the brunt of the adjustment," says Richard O'Brien, chief economist of the American Express Bank in London. He calculates that with swifter productivity growth, a dollar-yen exchange rate from 180 to 200 yen would have been low enough to have restored America's competitive position. "Factoring in relatively low productivity growth, however, takes the dollar to 150 yen or lower," O'Brien says. Continuing downward pressure on the dollar has already flashed ominous signs of higher inflation and interest rates—both enemies of faster economic growth. Productivity remains the best escape from the dismal arithmetic.

Joan Berger in New York, with bureau reports



TOP AND BOTTOM BY ROGER GORMAN

MAKING BRAWN WORK WITH BRAINS

U.S. factories must innovate as fast as labs invent

Back when most homes had black-and-white TVs and dial phones, before U. S. inventors had dreamed up microwave ovens, quartz wristwatches, and videorecorders, this country thought it had a lock on the good life. After all, U. S. factories were spewing out a steady stream of low-cost consumer goods that the whole world was lapping up. In his 1958 classic, *The Affluent Society,* John Kenneth Galbraith could confidently boast: "We have solved the problem of production."

Not quite 30 years later, things couldn't be more different. The American standard of living is slipping. Even the country's once-unassailable lead in high technology is narrowing: Japan produces and uses more computer chips than does the U. S. And it is coming on strong in biotechnology and gearing up for a massive assault on what could be the next major new technology—superconductivity (BW—Apr. 6).

Meanwhile, U. S. factories are producing a rapidly dwindling share of the products that made this country an industrial powerhouse. Starting with steel and machine tools, then consumer electronics and automobiles, the U. S. share of world exports has ebbed in one industry after another. Imports, meanwhile, are flooding U. S. shores. Buy a quartz watch or a VCR and odds are it will be made by a foreign company. In just the past six years, America's trade balance in manufactured goods has plummeted sharply into the red, from a surplus of $18.1 billion to a deficit of $151 billion. Even high-tech electronics products have been running a negative balance since 1984. Last year they posted a $13.1 billion deficit—49% bigger than in 1985.

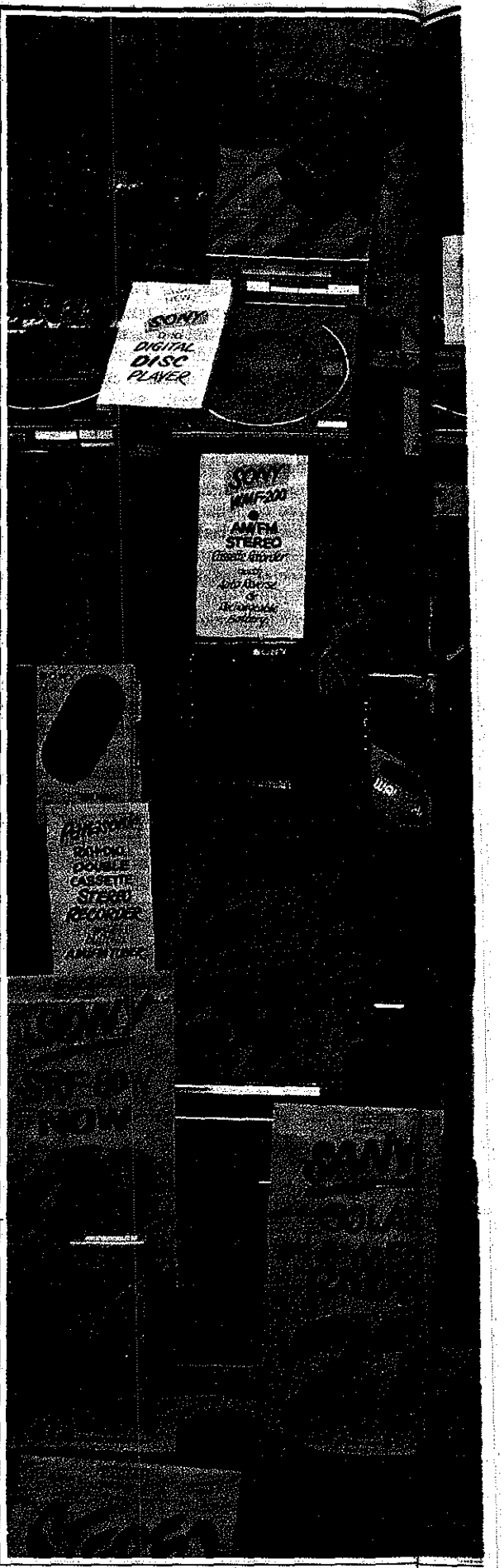
The crisis in U. S. competitiveness has sparked a spate of studies by federal agencies, academia, and industry—no fewer than 17 major ones in the past few years. Their recommendations are familiar: Spur technological innovation by pumping up research and development, forge bonds between industry and academia, and turn out more scientists and engineers. These areas can bear improvement, and some positive steps are being taken (page 68).

But such actions beg the question. The fact remains that the U. S. is still a creative hothouse. Its laboratories churn out important advances and whole new technologies, from biotechnology and fiber optics to superconductivity. And foreign students flock to U. S. universities, where they now account for 20% of all students and a staggering 55% of those studying engineering. So the failure is not American technology—it is American manufacturing. U. S. industry has big trouble when it comes to transforming ideas into products that can be sold on world markets. That's the missing link in the innovation process.

Unless the U. S. gets its manufacturing operations back in shape—and fast—it could lose any hope of maintaining the foundation on which tomorrow's prosperity rests. That task is so urgent, says Harris Corp. Chairman Joseph A. Boyd, that it calls for a commitment on the scale of President Kennedy's program to put a man on the moon. And the process won't be painless, warns Roy H. Pollock, who recently retired as RCA Corp.'s executive vice-president for technology and now lectures at Fordham University. "With the exception of the Civil War, it's doubtful that America has ever faced such an awesome trauma. But the alternative," Pollock says, "is to accept continuing economic decline and the end of America's greatness."

DEAD ENDS. What happened to U. S. factories? All fingers point to the corner office. For most of the 1900s, "we were the quintessential manufacturing society," says Herbert W. Nidenberg, an industrial engineer who is now senior program manager for manufacturing at Battelle Memorial Institute. And that evolved into arrogance. "Coming out of World War II, we got the idea we were much better than we were," says Steven C. Wheelwright, professor of manufacturing strategy at Stanford University.

Galbraith's assertion that production



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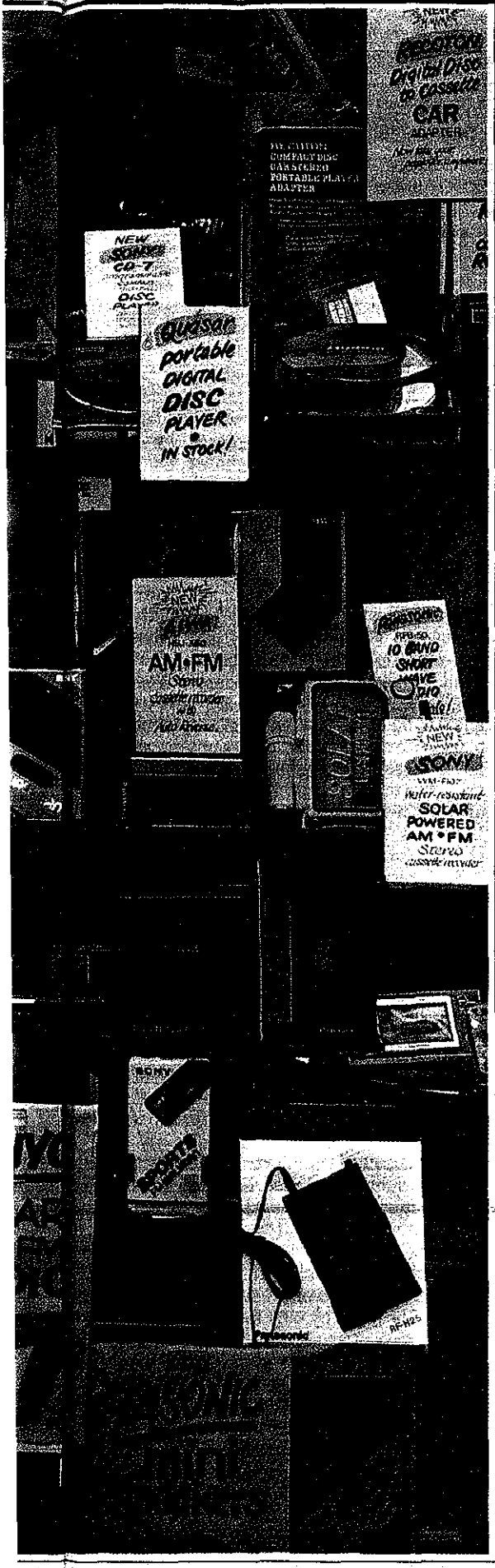


had been mastered reflected the prevailing view of top executives in the 1950s. By then, manufacturing had ceased to be a factor in strategic planning. Factories had been handed over to caretaker managers in dead-end jobs. Their assignment was simple: Don't do anything risky, just keep the production line humming. More and more factory jobs were reduced to boring, repetitive chores that anyone could do, and the pool of skilled machinists withered.

The upshot: By the time Japan emerged as a serious challenger in the late 1960s, the U. S. was saddled with an alienated work force and moribund factory managers. They didn't have a prayer against Japan's dedicated workers and energetic engineers. Twenty years later the situation isn't much better, because few senior managers have yet come to grips with the enormity of the feat that Japan has pulled off.

STUNNING SPEED. Even after Japanese auto makers had knocked Detroit for a loop in the late 1970s, General Motors Corp. was totally unprepared for the miracle of NUMMI. In setting up New United Motor Mfg. Inc., managers from Toyota Motor Corp., GM's partner in the joint venture, took a mothballed California assembly plant with outmoded equipment and transformed it into GM's most efficient factory. GM executives, who have long patted themselves on the back for being America's most progressive managers, were staggered. "Productivity there is twice the average level in GM," says David J. Teece, director of the Center for Research in Management at the University of California at Berkeley. "Yet here is a plant where nothing special is going on in terms of technology." The difference is the way that the Toyota managers organized and operate the NUMMI plant.

Indeed, that's the secret to how the Japanese pulled the rug out from under U. S. manufacturing. They figured they could break America's stronghold in many markets only by offering customers a broader choice of goods. That would attack the key weakness of mass manufacturing: It depends on long, stable production runs. By totally revamping the factory and finding methods that could rapidly inject a stream of new products into the market, the U. S. would be unable to keep pace.

It was a stunning strategic coup that marked the end of an era. The Japanese created a manufacturing infrastructure that can respond with blazing speed to market demands and changing opportunities. Products are designed from scratch not only for ease of assembly—with an emphasis on simplicity and the fewest parts possible—but also for easy modification. Factories are organized by product, not by function, so that raw materials enter a manufacturing "cell" and exit as a finished product or component. Unlike U. S. operations, there is no so-called work-in-progress waiting for a drilling machine, then moving into another queue until it can be processed on a grinding machine. And the whole soup-to-nuts production is orchestrated with such precision that it runs with virtually no inventories of purchased parts and materials or of partly finished products—all of which tie up money.

NEW CYCLE. Moreover, the Japanese put the craft back in manufacturing by making quality the responsibility of each worker, not after-the-fact inspectors. Jobs that need only mindless hands are delegated to mindless machines: robots. And while it seems unbelievable to many Americans, this approach yields products that are both higher-quality and less expensive. Almost overnight the precepts of decades of manufacturing science were turned upside-down.

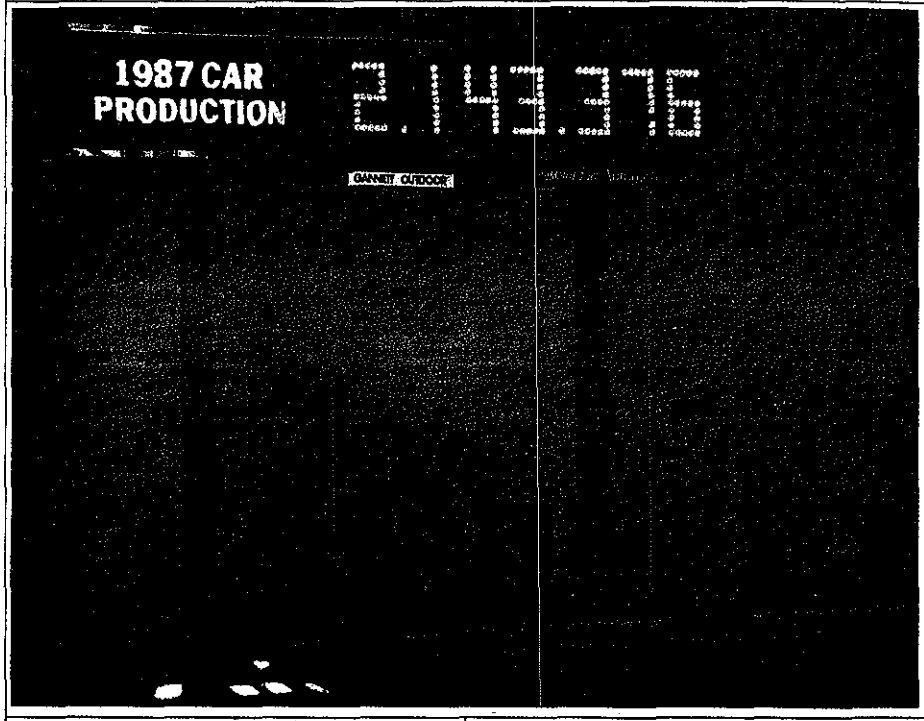
The full dimensions of Japan's achievement are finally beginning to sink in. But few U.S. companies have the manufacturing talent necessary to mount an effective response. The experts can tick off only 30 or so major corporations that are clearly serious about manufacturing: Allen-Bradley, GM, and IBM usually head the lists. Close behind are such names as Apple Computer, Caterpillar, Deere, Hewlett-Packard, Honeywell, Johnson's Wax, 3M, Xerox, and the major aerospace companies.

General Electric Co.'s $11.6 billion investment over the past six years to

CONSUMER ELECTRONICS

TRADE BALANCE: -$11 BILLION

In the early 1960s, the U. S. produced nearly 90% of the color TVs made in the world. Now, more than half are made in Japan. That country also controls more than 90% of the world video-recorder market. Last year, domestic producers supplied just 38% of consumer electronics sales in the U. S., down seven points from 1984—and several are Japanese-owned. Philips of Holland teamed up with Sony Corp. when it rolled out the hot-selling compact disk only because there was no suitable U. S. partner.



AUTOMOBILES
TRADE BALANCE: -$31 BILLION
U. S. factories turned out nearly half of the world's cars in 1960. Today, Japan is close to claiming that distinction. Last year, imports accounted for almost 30% of U. S. auto sales, and the Commerce Dept. predicts foreign cars will grab 37% of domestic sales by 1990.

boost competitiveness wins it a place on that list. But more telling than the money, says Fred W. Garry, vice-president for manufacturing, is a change in managerial mindset: "the idea of looking at things from a total-cost point of view," not each manager's narrow specialty. In GE's major appliance business, people from design, marketing, and manufacturing now huddle at the start of a development cycle to coordinate the project. The payoff: Japanese competitors that had been planning to go after the U. S. market for refrigerators and washers and dryers have been spooked. Better products, Garry believes, "delayed their decision and maybe aborted it."

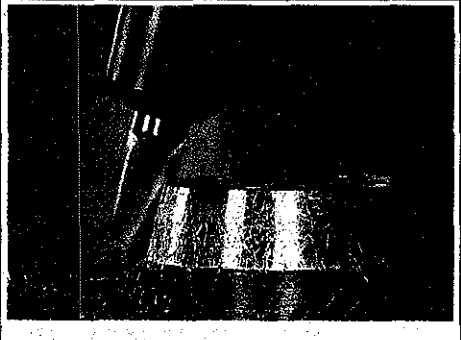
PROWLING ENGINEERS. Black & Decker Corp. pioneered exercises in product simplification a decade ago. By trimming the number of components in its power hand tools to increase productivity and reliability, B&D multiplied sales sixfold during the 1970s while cutting prices in half. The concept works just as well with huge locomotives. At GE's Erie (Pa.) factory, engineers prowl the plant, asking workers for ideas to improve productivity. Case in point: Shop workers thought a complicated door, which took sophisticated equipment to produce, could be simplified. The door is now built with simple tooling, using 40% fewer parts and costing 25% to 30% less.

Since 1980, Westinghouse Electric Corp. has been stressing greater flexibility, defect prevention instead of defect detection, and "bottom-up" management in production. It created a 300-person Productivity & Quality Center to carry the message to every plant, and several thousand hourly employees are now organized in work teams that are responsible for their own supervision. Westinghouse has also invested more than $2.4 billion to improve manufacturing. That helped boost net income to $671 million last year, nearly 50% above the 1983 mark, on a 13% sales rise to $10.7 billion.

The programs were triggered by a 1979 internal study. Westinghouse wanted to know why it was getting its pants beaten off in quality by the Japanese. The answer quickly became apparent. The Japanese measure quality in terms of "composite yield," or the percentage of work done right the first time by each worker. Westinghouse sampled quality at the end of the production line, often oblivious to the rework before that point. Applying Japan's standards, Westinghouse was shocked to learn that its quality was as low as 15% in some plants. "As incredible as it sounds, we never measured our output in this manner," wrote Thomas J. Murrin, president of the Energy & Advanced Technology Div., in 1979. Quality has since jumped sharply, to as much as 90%.

Such results are typical when enlightened managers apply new technology—even without climbing the automation ladder all the way to computer-integrated manufacturing (CIM). That involves creating a single shared data base from which plans for operating not only the factory but all other departments are drawn (BW—June 6). The hangup with CIM, says Henry J. Johansson, head of manufacturing consulting at Coopers & Lybrand, "is that it crosses all functional lines, so there's a turf battle."

RESCUE MISSION. On the rung below CIM, companies have installed either flexible manufacturing systems (FMS) or direct links between computer-aided design (CAD) and manufacturing (CAM) systems. Such moves typically trim production time, scrap and rework, inventories, and direct-labor costs by 50% to 85%, according to a recent study by Booz, Allen & Hamilton Inc. An FMS is a cluster of computer-controlled machines that can be quickly programmed to turn out any one of a family of parts—for example, anything that can be machined from a block of steel up to a certain size. CAM systems are similar but can integrate more types of production equipment. With both FMS and CAM setups, produc-



MACHINE TOOLS
TRADE BALANCE: -$1.7 BILLION
America's share of world machine-tool exports has plunged from 23% in 1964 to about 4% today. Over the same period, imports soared to 47% of the domestic market, up from 4%. The Administration acted in 1986 to halt the slippage: It won five-year voluntary restraint agreements from exporters in Europe and Asia. The industry hopes that signals the start of the long march back.

PHOTOGRAPHS BY (TOP) PETER YATES; (BOTTOM) GARY KESSLER

AMERICA'S R&D PERFORMANCE: A MIXED REVIEW

The key to the future ability of U.S. industry to compete successfully in the international marketplace lies in the country's research and development efforts. Most of the research experts consulted for this report agree that the U.S. overall is still a leader in technology. But many competitors are closing the gap. So here, by the U.S. would be well advised to make Morgan Stanley's assessment of the health of the U.S. research enterprise.

INDUSTRIAL R&D

What's good. After the doldrums of the 1970s, research and development spending by industrial companies surged back. During the past decade, companies have stepped up the amount of money they spend on new products and processes by nearly 10% a year—almost twice the rate of inflation. In 1987 they will spend close to $60 billion. There are also fledgling groups of firms or whole industries that are very much competitive. Such companies as Microelectronics & Computer Technology Corp. are going head-to-head with the organized efforts of Japan's Ministry of International Trade & Industry. The Defense Dept. has promised to help fund Sematech, a consortium, to develop manufacturing technology for computer chips.

What's wrong. The growth rate of industrial R&D spending may be tapering off. Estimates of company spending collected by the National Science Foundation indicate that industrial R&D may have edged up only 0.6% in 1987. That's even worse in real terms, because the cost of research is increasing rapidly. The share of U.S. patents granted to foreign inventors is rising. In 1986 fewer than 53,000 of the 77,000 U.S. patents issued were granted to citizens of foreign countries. In 1986 they accounted for almost half of all U.S. patents—nearly 20,000 in foreign companies compared with 21,000 to U.S. inventors. In addition, the recent spate of mergers and acquisitions is consolidating many R&D outfits. Thousands have been reported at Phillips Petroleum, Cyanamid, Zellerbach, Allied-Signal, Gulf, and so on.

BASIC SCIENCE

What's right. The Reagan Administration has championed basic science that leads to new technology. Over the past six years, federal support of such research, largely at universities, has jumped by 50%, to $8.7 billion. The Administration is backing proposals to double the budget of the National Science Foundation, to $3.2 billion, over the next five years. U.S. industry has increased the number of research partnerships with universities in recent years, to 450, estimates Coleman.

The government is also encouraging better links between academia and industrial researchers. The NSF has set up 50 interdisciplinary university centers aimed at solving problems for industry. With $5 million in seed money from the NSF, the centers expect a total of $15 million from industry and state sources from the start in 1985. In a similar program, the NSF has established 19 Engineering Research Centers since 1985, with plans to add



INDUSTRIAL R&D SPENDING IS RISING, BUT EXPENSES ARE CLIMBING EVEN FASTER

12 more during the next five years. In addition, a number of states are setting up their own R&D centers to work with local companies.

What's wrong. The foreigners' share of the U.S. Ph.D. market has expanded rapidly. Of the total conferred in 1985, 12,000 were awarded to U.S. citizens and 5,000 to non-U.S. citizens. And the proportion is certain to keep increasing. The share of Ph.D.s in the sciences awarded to U.S. citizens has risen from more than 70% in the mid-1960s to only 50% this year.

In the natural sciences, the number of universities which exhibit more than 50% of the nation's basic research is declining. The Association of American Universities in Washington, D.C., estimates that U.S. universities are unable to fill even about half of their accumulated research facility needs. There has been a drop in new construction at state-supported schools for the past five years.

Moreover, foreigners are taking greater advantage of U.S. basic research facilities than are U.S. scientists. Some foreign universities are running

EDUCATION

What's right. The U.S. has a unique system of higher education that encourages the kind of creative thinking that leads to scientific breakthroughs. That's why U.S. universities are packed with foreign students who now make up 18% of all Ph.D. candidates in the country, up from 9% in 1966.

Japan and some other countries are making a concerted effort to improve their own science education. The Soviet Union has more engineers per million people than the U.S. Japan and Germany have more scientists and technicians per capita than the U.S. In addition, the European Economic Community's Esprit program, a research and development consortium for electronics and computer technology, has 226 projects under way.

What's wrong. The quality of education in the U.S. is uneven. Over the past two years, there has been a growing chorus of complaints about the poor quality of science and math education in the U.S. Many students graduate from high school with little knowledge of science and math. Many of the country's best and brightest students are lured away from careers in science by the promise of more money in business and law. Many of the country's best science and engineering graduates are snapped up by industry, leaving academia with a shortage of teachers and researchers. In addition, the Reagan Administration has cut federal support for graduate education. The National Science Foundation, for example, has reduced its graduate fellowship program by 50% since 1981.

The U.S. is also losing ground in the number of students graduating in the hard sciences. In 1985, U.S. colleges awarded 24,000 bachelor's degrees in engineering, down from 77,000 in 1985. Only 4% of undergraduates in the U.S. major in engineering, compared with 20% in Japan and 25% in Taiwan. Only 5% of U.S. undergraduates major in the natural sciences, compared with 15% in Japan. In 1984, the U.S. ranked 14th among 15 countries in the number of 24-year-olds with degrees in science or engineering. In 1985, U.S. students ranked last among seven countries on comprehensive achievement tests in the Second International Mathematics Study. U.S. 13-year-olds ranked 12th or below out of 15 countries in geography, advanced algebra, and calculus. Students from Hong Kong and Japan ranked first and second, respectively, in each subject.

As the college-age population declines, the number of students graduating in the U.S. with science and engineering degrees will continue to fall over the next decade, creating an acute shortage. In 1985, U.S. schools graduated fewer than 5,000 Ph.Ds in engineering and mathematics, but this is less than half the number of U.S. students planning to pursue Ph.Ds in science and technical fields. Moreover, the number of foreign students graduating with Ph.Ds in these fields is expected to increase only slightly over the next decade.

KEN KERBS

tion runs of one part become feasible.

Stanford's Wheelwright takes heart from these signs. "Fundamental changes are beginning to happen," he says. "But there have to be many more companies involved if we are going to bring manufacturing back." The major stumbling block is persuading management to invest in new technology—especially at the country's 150,000 small to medium-size job shops. Many of these companies face problems "that can put them out of business in months," warns Thomas G. Byrer, manager of Battelle's manufacturing and materials processing department. "They don't have five years to wait for help."

So Battelle has refocused its Manufacturing Modernization Project specifically on smaller manufacturers. To get the word out, Battelle is enlisting the aid of local utilities—26 so far—that include small manufacturers among their customers. And it has established a toll-free number, 800-824-0516, that shop managers can call with problems.

The Navy has launched a rescue mission, too. It's called RAMP, for Rapid Acquisition of Manufactured Parts. The Navy wants to be able to request bids for replacement parts and get delivery 30 days later. Today that process takes 300 days. Trimming the cycle by 90% is attainable—and it can be done with existing, proven technology, according to a study presented to the Navy late last year by the South Carolina Research Authority, based in Charleston.

GOING FOR BROKE. So the Navy has decided to steam ahead and apply that technology to an "ultimate job shop"—and make the technology available to all comers, not just Defense contractors. Scheduled to be up and running in 1990, the plant will automatically make anything that can be carved from a 12-in. metal cube or a cylinder 6 in. in diameter and 24 in. long. The shop is designed for a work load of 86,000 metal parts per year, in batch sizes as small as one.

A comparable prototype job-shop-of-the-future has already been demonstrated by a consortium called Impact, headed by Big Eight accountant Arthur Andersen & Co. And the National Bureau of Standards last December dedicated its Automated Manufacturing Research Facility, a factory-automation laboratory where companies can test production concepts. Even so, the scope of modernizing smaller plants is so vast that Stephen S. Cohen, co-director of the Berkeley Roundtable on the International Economy at UC Berkeley, believes Washington should establish an industrial extension service similar to the agricultural Cooperative Extension Service.

Justifying the cost of new technology is probably the main sticking point at most companies. Cost-accounting schemes rely chiefly on savings from direct labor to recover capital investments. But in most industries, labor has already been trimmed to the bone and represents only about 10% of production costs. Even squeezing out all remaining labor expenses wouldn't be sufficient to justify the investments needed.

'HAVE FAITH.' "Tying everything to just direct labor is no longer valid," argues J. Tracy O'Rourke, president of Allen-Bradley Co. "The nondirect cost areas—inventory requirements, product flow-through, and quality—have to be considered more closely," he says. "The normal capital-budgeting process, using discounted cash flow based on hard savings, has gotten in the way" of efforts to modernize, agrees John J. Clancy, president of McDonnell Douglas Manufacturing & Engineering Systems Co. It's difficult to forecast tangible benefits based on better quality and faster product introductions. Yet such intangibles can often affect a company's market share more than its prices do. Until now, O'Rourke quips, there was only one answer to this dilemma: "As the preacher says, you've got to have faith."

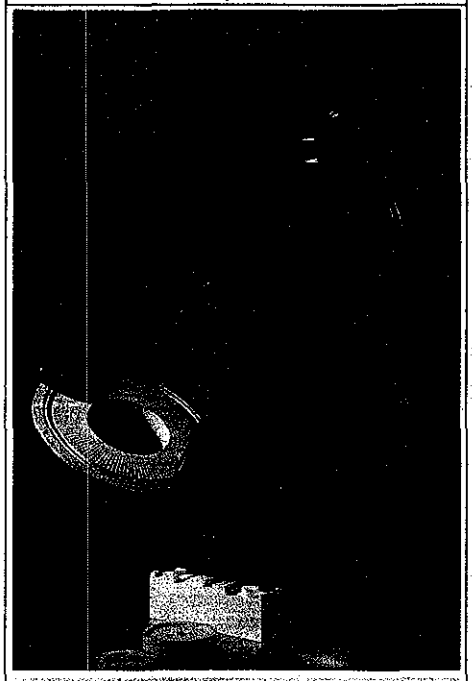
Not many companies are willing to make multimillion-dollar investments on those terms, largely because top management doesn't really understand manufacturing. "You don't find too many manufacturing types in top jobs in U.S. corporations," notes Mark Shepherd Jr., chairman of Texas Instruments Inc., who is one of the rare top executives from the "dirty fingernails" school—and proud of it. Managers who lack a feel for the shop floor cannot expect to dictate results and cooperation, he adds. "The boss can't be just the boss today; he has to be a leader."

For conservative executives, the outlines of a whole new approach to cost management and capital budgeting will shortly be released by Computer Aided Manufacturing-International Inc., a factory-automation research co-op in Arlington, Tex. The CAM-I plan was more than a year in the making by a task force composed of all the Big Eight accounting firms, 30 industrial companies, and the three armed services. "It's the first time I've seen the Big Eight working together on anything," says Johansson of Coopers & Lybrand.

IDEA FACTORY. The initial report will sketch the framework for evaluating such intangibles as how higher quality or faster delivery can translate into improved market share and fatter revenues. This year the task force will develop specific policies and procedures. "Even the bean counters are excited," says Richard B. Troxel, head of financial management practices for Peat Marwick Mitchell & Co., "because it means the financial people will be more involved in formulating strategic decisions." Hanging a dollar sign on the factors that enhance strategic competitiveness, adds Johansson, is vital: "Otherwise, you're not going to get off the dime in manufacturing modernization."

The U.S. cannot afford to let that happen, especially now that Japan is also starting to undercut America's role as the world's idea factory. In the past, says H. Kent Bowen, director of Massachusetts Institute of Technology's Manufacturing Systems Engineering & Management Program, the U.S. was dominant in technology and Japan had the advantage in manufacturing. "But if they get both, where does that leave us?" It's time management took to heart the old saw: People are a company's most valuable asset. And a factory's.

By Otis Port in New York, with John W. Wilson in San Francisco and bureau reports



JIM JUOKIS

HIGH-TECH CERAMICS

TRADE BALANCE: TOO SOON TO CALL

Stronger than steel, as heat-resistant as refractory bricks, and diamond-hard, ceramics might be the plastics of the 1990s. As engines for cars, planes, and power generators, they would be lighter than metal and nearly indestructible. A race is on to develop the processing technology that will turn the promise into reality. The U.S. had the lead in the early 1980s; now experts give Japan the edge.

GETTING MAN AND MACHINE TO LIVE HAPPILY EVER AFTER

Management and labor must rewrite the rule book to make flexible manufacturing pay off

Only people, says Japanese labor expert Haruo Shimada, can "give wisdom to the machines." It's a lesson that leading-edge U. S. companies are beginning to learn. By integrating multiskilled, highly trained workers and computer-driven technology, these companies are seeing remarkable gains. They could represent the wave of the future in manufacturing—but only if management and labor discard obsolete practices and collaborate on innovative production systems.

A startling concept is starting to take hold in the workplace: Capital and labor are no longer competing inputs in production. The mechanization of muscle-power in the first Industrial Revolution led to simpler and simpler tasks that demanded little of workers except the use of their hands. Management neither expected nor wanted broader worker involvement. In the new Industrial Revolution now under way, capital consists of information technologies that require workers' mental commitment and responsibility for entire systems rather than for narrow tasks.

BREAKING BARRIERS. Integrating the work of robots and other computer-controlled machines in networks requires "a collection of people to manage a segment of technology and perform as a team," says Richard E. Walton of Harvard business school. Capital and labor interact in a different way, calling for new arrangements that aim especially at involving workers in decisions to a far greater degree.

The people-machine symbiosis is especially powerful in American plants that are operated under "sociotechnical" principles. These innovations mesh workers' social and psychological needs with technological requirements. Semiautonomous work teams and other innovations enable some plants to be 30% to 50% more productive than conventional ones. Many leading companies have adopted the work-team approach, including Procter & Gamble, Cummins Engine, GM, GE, Westinghouse, IBM, Xerox, and Polaroid.



WESTINGHOUSE'S FURNITURE PLANT: CUSTOMERS REGULARLY VISIT TO TALK WITH WORKERS

MICHAEL L. ABRAMSON

This burst in productivity is happening mainly in new plants, outfitted with advanced machinery and designed specifically with sociotechnical methods in mind. The semiautonomous team concept needs nurturing; quick-fix, cookie-cutter methods won't do. Nor is it applicable to all situations. But the use of teams and other work reforms in conjunction with technology can speed productivity growth in manufacturing.

Still, barriers must be broken to make the work climate hospitable to innovation. The old-style "control" methods of managing people impedes the growth of worker commitment. Companies must adopt participatory management, eliminate bureaucratic layers of supervisors, listen to employees, and develop job-security and retraining programs. Workers generally want to do a good job and will suggest work efficiencies if they feel that their jobs are secure. Furthermore, "gain-sharing" and "pay-for-knowledge" compensation systems encourage workers to learn new skills and raise productivity.

LOOSENED CONTROL. Unions, meanwhile, must move from a slavish dedication to narrow job classifications and other work rules that restrict shop-floor flexibility. Every manufacturing industry has some local unions that have loosened their control over the shop floor in return for more participation in departmental and plantwide decisions. National leaders of the Auto Workers, Steelworkers, and Electronic Workers support these and other changes in traditional union policies, although they still face internal criticism for doing so. Examples of highly participative, flexible plants are growing in basic industries such as autos, electrical equipment, tires, aluminum, and steel.

What makes this manufacturing flexibility possible is a high degree of worker involvement in decision-making. About 65% of the 830 employees at the Grand Rapids (Mich.) plant of Westinghouse Furniture Systems, a unit of Westinghouse Electric Corp., are involved in an elaborate system of committees and ad hoc task forces that discuss issues ranging from business strategy to the constant redesign of work areas for product innovation. Using computer-aided design and computer-controlled production, the plant can switch rapidly from one special order to another, combining standard parts in unlimited permutations. From 1983 to 1986, productivity—defined as constant sales dollars per employee—increased by 74%, according to general manager Russell A. Nagel.

Although the Westinghouse plant has

machines, blue-collar workers, and even a union—the United Brotherhood of Carpenters—it functions more like a service-type industry than an old-fashioned factory. Shop-floor workers consult frequently with customers who phone or visit the factory to check on the progress of their orders. As in a top-quality French restaurant, everything is aimed at pleasing the customer, including high product quality and short delivery time. Michael Maccoby, a pioneer consultant on work reform, says the Westinghouse plant is a leading example of a "techno-service" mode of production that is replacing the old "industrial bureaucracy" systems that crank out unvarying, mass-produced items. To become competitive, Maccoby says, companies must "get away from the bureaucratic industrial mentality which is oriented to output, not to quality or the customer."

The most comprehensive outline of a "strategy of permanent innovation" appears in *The Second Industrial Divide*, a book by Michael J. Piore and Charles F. Sabel. Under their concept of "flexible specialization," manufacturing would be performed in small companies or decentralized units of large ones, based on the organization of work along craft lines. Skilled workers, using automated machinery, could change quickly from one product line to another without the restrictions of union shop rules. Piore and Sabel concede that the U. S. may be unlikely to adopt such a system nationally, but they note increasing evidence of changes in that direction.

RETAILORED TEXTILES. A good example of flexible specialization involves the Amalgamated Clothing & Textile Workers Union and its centralizing role in helping the U. S. textile and garment industries compete with low-wage foreign labor. The ACTWU and manufacturers in both industries have formed a joint venture, Textile Clothing Technology Corp., to develop new technology for clothing factories. A prototype automatic sewing machine, now being tested in several plants, speeds up the difficult task of sewing sleeves in all kinds of clothing. "The quicker it takes to turn around from order to delivery, the better we'll compete with offshore production," says ACTWU Secretary-Treasurer Jack Sheinkman. "We don't intend to reduce our wages to the lowest common denominator."

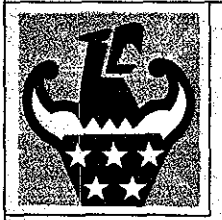
Warren Bennis, an expert on organizational behavior, explained years ago why worker involvement is essential in an innovative plant. "Democracy," he wrote, "is the only system of organization which is compatible with perpetual change."

By John Hoerr in New York

FOREIGN ALLIANCES

MAKING DEALS THAT WON'T GIVE TECHNOLOGY AWAY

Companies try for new kinds of international collaborations



To skeptics, the forming of high-technology partnerships with the Japanese is tantamount to making a pact with the devil. But with Japan collecting an ever-growing share of world chip sales—40% last year, up from 35% in 1985—more and more U. S. chipmakers are deciding to chance a little fire and brimstone. Even the leading American companies feel that the gamble for a bigger slice of Japan's silicon pie, now the world's largest chip market, is worth the risk.

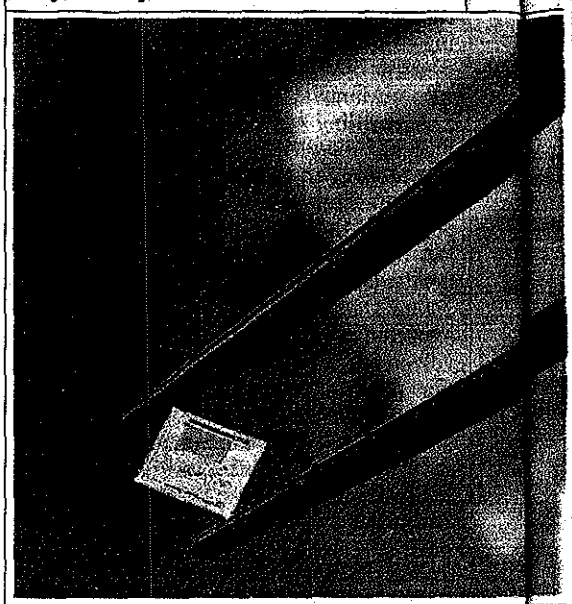
Take Motorola Inc., the No. 2 U. S. chipmaker after Texas Instruments Inc. Its global market sbare is a respectable 6% or more. But sales in Japan are microscopic, despite 20 years of trying. So Motorola has cozied up to Toshiba Corp., Japan's No. 2 producer, in a precedent-shattering deal—the closest, most sweeping, and possibly riskiest collaboration ever between the two camps. Over the next five years, Motorola will swap its most precious and sensitive technology for some of Toshiba's, plus help in penetrating the Japanese market.

Other recent examples include Fujitsu Ltd.'s ill-fated attempt to buy Fairchild Semiconductor Corp. and a mysterious deal between Advanced Micro Devices Inc. (AMD) and Sony Corp. that neither will talk about. Market researcher Dataquest Inc. counts at least 27 alliances formed last year between Western and Japanese companies. "Strategic partnerships are becoming an irrevocable piece of every company's strategy," says Ralph J. Thomson, a senior vice-president at American Electronics Assn.

MORE COMPLEX. Such pair-ups have been proliferating for several years in industries as diverse as automobiles, office automation, and robots (BW—July 21). Consultants such as Kenichi Ohmae of McKinsey & Co. argue that the alliances are essential as business grows more complex and global.

But semiconductors are a particularly vital business, arguably more fundamental to the commercial and strategic well-being of the U. S. than any other technology. That's why Thomson and others worry that teaming up with foreign competitors, especially the Japanese, will only accelerate the drain of technology from America.

The critics have history on their side. For 25 years, U. S. companies have been licensing technology to overseas rivals. Arrangements that looked at first like the deal of a lifetime often wound up seeming Mephistophelian. Lionel H. Olmer, former Commerce Under Secretary, calls past alliances "a fire sale of the first order—the technology has gone for a fraction of what it cost to develop." Now pessimists fear that history is repeating itself in chips—in spades. Says Charles H. Ferguson, a fellow at Massachusetts Institute of Technology's Center for Technology Policy & Industrial Development: "If nothing substantial changes, the U. S. semiconductor industry will be gone in five years."



A study of the industry's problems was released in mid-February by the Pentagon's Defense Science Board and instantly fueled the growing protectionist sentiment in Congress. It cites an "unacceptable" reliance by the Defense Dept. on imported chips and urges major government assistance—$2 billion over the next five years. The money would help underwrite a Semiconductor Manufacturing Technology cooperative (Sema-

tech) to develop new production methods. Last month, authorization to spend $100 million a year was tacked onto an omnibus trade bill by Representative Don Ritter (R-Pa.).

While the plight of the semiconductor industry has captured headlines of late, Administration officials are also uneasy about the growing trend to "internationalization" in general. George H. Kuper, executive director of the National Research Council's Manufacturing Studies Board, is drumming up funds for a close look at joint ventures with foreign companies, U.S. investment overseas, and direct foreign investment in America. Kuper has had informal requests for the study from the Commerce and Defense Depts. and other agencies.

Kuper believes the results might make American executives "a bit more wary of some of these arrangements." Not only do 7 out of 10 joint ventures fail to achieve their aims but also the Japanese seem much more able to exploit such ventures. The Japanese, he explains, do their homework. "They've had 20,000 people tramping through American factories in recent years; we visit the temples of Kyoto."

For U.S. chip producers, though, there are few options. W.J. Sanders III, chairman of AMD, explains that it is essential for American industry to improve its manufacturing and process technologies. "This means that we must enter into mutually beneficial strategic alliances with the best microelectronics producers, wherever they are in the world."

With the pace of development quickening and the costs of production soaring, it is increasingly difficult for U.S. chipmakers to go it alone. "There is a certain critical mass that has to be achieved," says Ronald J. Whittier, marketing vice-president at Intel Corp., "and no single company can do this by itself." That's why Motorola Executive Vice-President James A. Norling opted to team up with Toshiba. Norling and others are convinced they can cut deals that will guarantee value in return.

Unlike the routine second-sourcing and design-licensing deals of the past, the new arrangements can involve equity participation, joint ventures, technology sharing, and even coordination of marketing and product-development strategies. For example, Motorola can buy Toshiba memory chips stamped with Motorola's name. If Motorola wants to produce the chips, says Tsuyoshi Kawanishi, head of Toshiba's Semiconductor Group, the U.S. company will get Toshiba's design and production technology—"and they can use it worldwide." Toshiba also will help Motorola penetrate Japan's markets through a joint venture in Japan.

Still, Motorola is proceeding cautiously: Its prized microprocessor technology will be transferred only in lockstep with improved sales in Japan. If all goes well, Norling asserts, "we will create a significantly greater market opportunity for Motorola's microprocessor architecture." Sheridan Tatsuno, senior analyst for Dataquest's Japanese Semiconductor Service, believes the move is a smart one. "Toshiba probably has the best memory technology now," he explains.

Some experts fret, however, that advanced microprocessor technology, still a major bastion of U.S. companies, should not have been allowed to fall into Japanese hands. If the government had been smart and forced open Japan's semiconductor market, says MIT's Ferguson, "Motorola wouldn't have had to trade technology for market access." Robert S. Heikes, American co-chairman of startup European Silicon Structures, also has doubts. "I hold out the possibility there is something about the deal that I don't understand. But I don't think it's a good deal. Even if it's good for Motorola, it's not a good deal for the U.S."

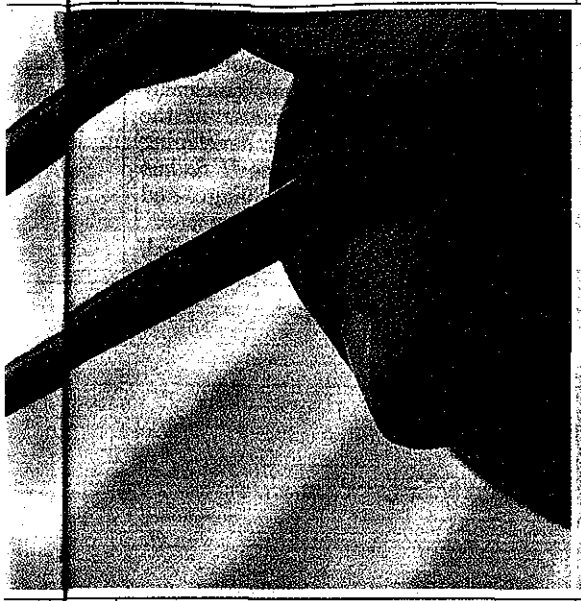
Although not as dramatic as the Motorola-Toshiba pact, other alliances have benefited American companies. LSI Logic Corp., for example, got started in the early 1980s largely by arranging for Toshiba to make its semicustom chips in exchange for the Milpitas (Calif.) company's design technology. More recently, it has lined up financing from Kawasaki Steel Corp. for a semiconductor plant in Japan. At current exchange rates, "an American company is facing a mountain of yen if it wants to invest in Japan," says Wilfred J. Corrigan, LSI's chairman.

In a tie-up with Japan's NMB Semiconductor Corp., National Semiconductor Corp. has avoided substantial capital costs by getting NMB to use an idle line to make static random-access memories for National. In return, NMB gains experience making state-of-the-art chips. Executive Vice-President James M. Smaha insists National is not giving away the store. "There is no question that NMB's goal is to be in the merchant business, but they would get there anyway."

CELL LIBRARY. Strategic alliances aren't limited to transpacific linkups, as the 1985 purchase of Mostek Corp.'s assets by France's Thomson attests. Now, Thomson is talking merger with Italy's SGS Semiconductor. Philips and West Germany's Siemens are spending more than $1 billion in their government-backed Mega Project, which is aimed at catching up with the Japanese in next-generation memory chips by 1990. Siemens, Toshiba, and General Electric are working together to develop a so-called standard cell library for semicustom chips. Siemens and Intel have cooperated closely for 11 years on microprocessor development and production.

Rather than barring U.S. companies from turning to offshore partners, some experts advocate easing America's antitrust laws to allow more domestic partnerships. That's happening, anyway. Late last month, giant Texas Instruments and Linear Technology Corp., a small California chipmaker with $30 million in sales, formed a long-term alliance to expand their business in analog chips. TI believes joint relationships are becoming so crucial that it has delegated Executive Vice-President William N. Sick Jr. to scour the country—that is, America—for potential partners. "We believe strongly in maintaining our core technology in the U.S.," says Sick. Customers, he adds, like it that way because "they see little difference between a U.S. company dependent on Japanese technology and a Far East supplier."

By Robert Neff in Los Angeles, with John W. Wilson in San Francisco, Michael Berger in Tokyo, and bureau reports



ROBERT HOLMGREN

U.S. LINKS WITH JAPAN

Some semiconductor deals cut in 1986

JOINT VENTURES	
Advanced Micro Devices	Sony
Chips & Technologies	Kyocera and Mitsui
LSI Logic	Toshiba
Motorola	Toshiba
Standard Microsystems	Sumitomo Metal
JOINT DEVELOPMENT	
Boeing	NEC
Catalyst Technologies	Oki Electric
General Electric	Toshiba
Vitelic	Tokyo Sanyo
EQUITY INVESTMENT	
Cambridge Instruments	Fuji Electric
Ion Beam Technologies	Marubeni Hytech
Perkin-Elmer	Citizen Watch

DATA: DATAQUEST INC.

PERSPECTIVE

IS THE U.S. GOING THE WAY OF BRITAIN?

What caused U.S. industrial power to fade, and how far the process might go

A decade or so of slowing growth, lagging productivity, and deteriorating competitiveness has gripped Americans with a fear that they are losing ground—and irreversibly at that. After all, cities grow and then shrink, nations advance and retreat, and empires rise and fall. Doesn't the ebb and flow of events tell us that the U. S., the world's greatest industrial power, will suffer Britain's fate and fall from grace? Will the mantle of economic leadership, having once passed from Britain to the U. S., soon pass from the U. S. to . . . Japan?

Not necessarily. History is not destiny, the U. S. is not Britain, and Japan is most definitely not the U. S. Still, historical patterns are an essential part of understanding how nations grow, and they give some insight into what lies in store for the U. S.

Economists and historians have developed varying frameworks for analyzing economic growth. Some have identified stages of growth, akin to the stages in human life. A related approach is to focus on industrial and technological advances as the impetus to change. Still others have attributed economic growth to the crossing of geographic frontiers. Recently, some experts have studied the role that government and institutions play in retarding or fostering growth.

SPICE MERCHANTS. These analyses deal mostly with modern history. That's because the pre-industrial age was characterized by far slower progress, and economic centers seemed to follow one surefire route to power: They traded their way to the top, or feasted on the spoils of war. From the 15th century city-states of Italy to the 17th century Dutch empire, gaining the upper hand with neighboring landowners or distant spice merchants was paramount.

Britain broke out of this pattern, and the U. S. broke the mold entirely. Most economists date the origin of the modern world's economy to the 18th century Industrial Revolution, which enabled Britain to grow through manufacturing. Yet the U. S. provides perhaps the richest and the biggest canvas, with an economy that has moved from farming to manufacturing and, finally, to services.

What has worked for America clearly does not work for everyone else, as the postwar experience of many developing countries has shown. But the U. S. has been a proving ground for change, and continues to serve as an example.

And that example has been very good,

THE STAGES OF GROWTH IN AMERICA



BATTLE OF CONCORD ▲
Revolution and independence free the colonists from British rule. A new nation throws off Old World restraints on liberty and growth.



WESTWARD HO! ▶
In 1803 the Louisiana Purchase opens the frontier to settlers and prospectors. The fertile plains and the mineral-rich mountains provide ample resources.



KING COTTON ▶
On Southern plantations, slave labor cultivates cotton, while factories spring up in the North.

THE RAILROAD ▼
The first transcontinental line, completed in 1869, symbolizes a new age, as nation-builders and robber barons alike promote industrial progress.



PHOTOGRAPHS BY BROWN BROS. (2); BETTMANN ARCHIVE (2)

even surprisingly so at times. The 1950s and the 1960s demonstrated spectacular growth in the U. S., on the order of 3.5% per annum, with many years coming in at 4% or more. "At the end of World War II," says economist Albert T. Sommers of the Conference Board, "the U. S. had the most powerful collection of economic stimuli ever available. There was a sense of rebirth, in the U. S. and in the world, that was unprecedented in economic history."

PENT-UP ENERGY. More than a decade of depression and five years of war had deferred consumer demand worldwide. The U. S. had printed money to finance the war effort, and the money was now there to finance all the deferred consumer demand. The U. S. had no real rivals because the industrial plant of much of Europe and Asia had been destroyed. Even technological progress had been suppressed. So the pent-up energy created a burst of growth. By contrast, recent growth in real output has averaged about 2.5% a year. That may seem a little low, says economic historian Walt Whitman Rostow, "but against the long sweep of American history, it's not a terrible figure."

Rostow is the father of the "stages of growth" theory of economic development. The first stage is a long period—a century or more—when the preconditions are established. Then comes a takeoff period lasting three decades or so, when growth is propelled forward. The final stage is a long period of sustained and "normal" growth. The rate of growth in a mature economy naturally slows down, while that of nations in the takeoff or early sustained-growth stages is still robust.

A glance at the average per-capita growth rates from 1973-86 tells the story. In the U. S., output per person grew 1.4% a year during the period, slightly ahead of Britain's 1.1%. West Germany and Japan, with more distance to make up after the war, show stronger gains. The newly industrialized nations show even faster growth (chart, page 66).

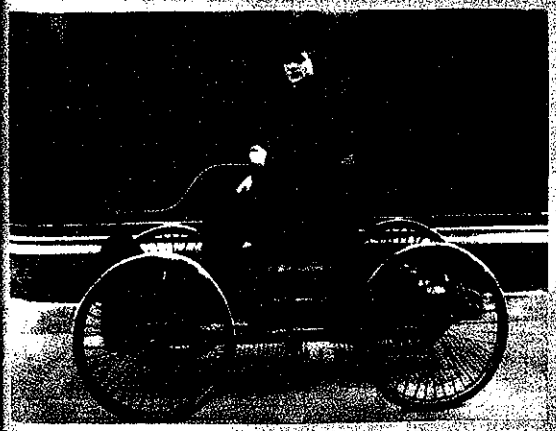
America is still waiting for the payoff from a surge in high-tech investment

The reason is simple, says Rostow. Technology has already been absorbed in the most mature nations, and only new technologies, well implemented, can affect the rate of growth. Other countries, however, are still absorbing old as well as new inventions and so are still "catching up."

Technology, in fact, has proved to be the key building block for growth, while resources, capital, and people are the raw materials. The best crop yields derive from new machinery and scientific advances. The most efficiently manufactured products are the result of careful design and up-to-the-minute production techniques. How far resources go, and how productive labor is, ultimately depends on technology. Without the first Industrial Revolution and the successive waves of innovation of the past two centuries, there would have been no growth as we know it.

In its early years, America provided a vast region rich in resources to waves of settlers seeking freedom of expression and opportunity. It was a favorable set of circumstances: The raw materials of growth combined in a new nation with new ideals, untrammeled by stultifying laws and restrictions. The citizens themselves were diverse, educated, and motivated—characterized by a spirit that today would be dubbed entrepreneurial.

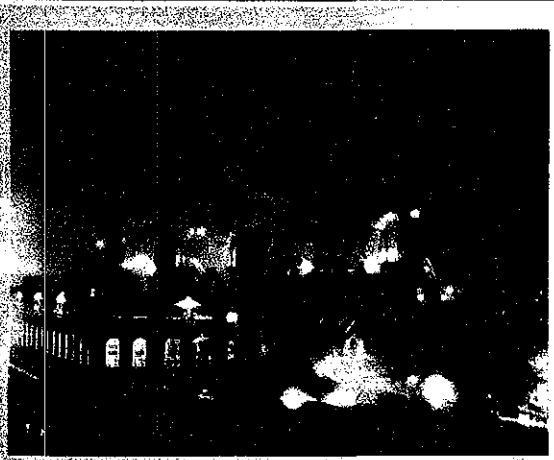
The fledgling nation began to exploit, in both the positive and the negative senses of the word, the resources and people at its disposal. The agrarian South grew as slave labor was forced to work the cotton fields. Even then, technology made a difference, as the widespread adoption of the cotton gin allowed for much swifter processing and great gains in output. In the North, textile mills and other light manufacturers



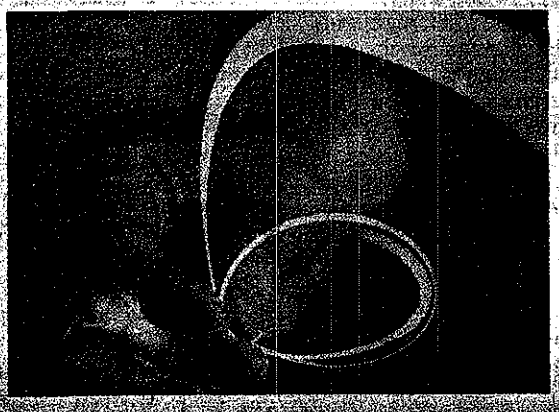
THE AUTOMOBILE ▲
Henry Ford introduces mass production for a mass market in 1908, as communications, electricity, and other advances sweep the nation.



J.P. MORGAN ▶
Wall Street grows with the economy. After World War I, the U.S. becomes a creditor to the world, but the 1929 crash brings on the 10-year Depression.



POSTWAR BOOM ▲
Its industrial plant undamaged, the U.S. emerges as a superpower after World War II. New technologies and pent-up consumer demand spur growth.



HIGH TECH ▶
Technology is now the big hope. A manufacturing economy built on superchips, fiber optics, and superconductors could give the U.S. a new competitive edge.

FOREIGN RIVALS ▼
Spoiled by success, the U.S. begins to lose its lead in the 1970s. As foreign competition builds in the 1980s, imports rocket and steel mills are shuttered.



CLOCKWISE FROM BOTTOM LEFT: BETTMANN ARCHIVE, BROWN BROS., BETTMANN, UPI, BETTMANN

were sprouting. But it was to the West that Americans looked to pursue and sustain dreams of freedom and economic opportunity.

So strong is the frontier notion that when the Superintendent of the Census reported in 1890 that the West had been so thoroughly settled that a frontier line could no longer be said to exist, the historian Frederick Jackson Turner was moved to write a paean to the significance of the frontier in American history. Turner mourned its passing and worried that its spirit would be lost.

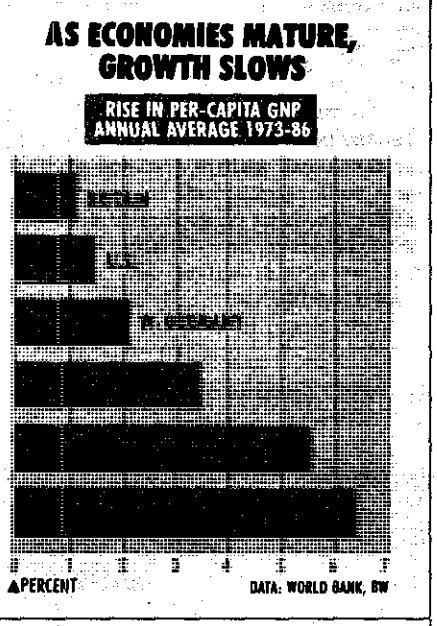
NEW FRONTIERS. He need not have worried. The Western frontier may have been exhausted, but technological frontiers were just opening up. By the late 19th century, inventions were coming fast and furiously, and by the turn of the century their application and acceptance was spreading across the nation. The telephone, the electric light, the automobile, and a host of time- and labor-saving machines became mainstays of daily life. Steel magnate Andrew Carnegie, at the onset of this period in 1889, wrote that "what were the luxuries have become the necessities of life."

That is, in one way, the essence of economic growth—the imperative that the standard of living should steadily be rising. Of course, this should be true for all citizens, not just a few. Carnegie would have abhorred the contemporary form of income redistribution by governments, but he welcomed the rise of individual progress that growth made possible. As nations grow, the distribution of income almost invariably improves, and so too, by definition, does the standard of living. Income distribution is far less equal in the developing countries than in industrialized nations.

Today the perception is growing that standards of living are slipping and the U. S. is following Britain into economic decline. The gloom is clearly exaggerated. The U. S. still ranks far and away as the largest industrial economy, while Britain is fifth. Britain's ranking, however, is being hotly challenged by Italy, in a tussle that highlights how important the direction of change is. Inevitably, an advancing nation appears more vital.

SETTING SUN. How did Britain lose its vitality? How did the birthplace of the steam engine, the cradle of industry, slide from preeminence? The Empire's defenders have long argued that Britain, as the pioneer, expended far more capital in breaking new ground than any successor did. What's more, they say, what Britain invented, the U. S. and others merely ran off with, eventually garnering the competitive advantage. This theft-of-technology argument is fashionable in Silicon Valley today, but it is largely beside the point. Few inventions remain secret for long; how they are utilized is what matters.

By and large, Britain simply ceded innovation to the U. S., and what it had, it used badly. It failed to reorganize its atomistic industrial structure into the corporate powerhouses needed earlier in this century to achieve the economies of scale demanded by mass markets. Economist William Lazonick of Barnard College argues in an analysis of Britain's cotton industry, which began to lose ground early in the early 1900s, that national supremacy over world markets had induced complacency. Across many industries, he says, too many producers simply operated within a comfortable status quo, without "engaging in innovative activity to alter constraints."



U. S. industry also has suffered from complacency. But this society has always made room for business pioneers who insist on doing things differently and, in recent years, created a Silicon Valley and a Route 128, while America's corporate giants struggled for survival. The U. S. has even managed to export a little of its entrepreneurial fervor to such nations as Britain and France. So what gives? Are we just waiting for the payoff? Will technology eventually be our salvation?

Quite possibly. But there may be something else at work, muting technology's impact. After all, the biggest surge in high-tech investment in the U. S. took place over the past decade, notes Stephen S. Roach, an economist at Morgan Stanley & Co., and by this time some results should be apparent. The problem, some economists believe, may be structural and institutional rigidity.

"Every long-stable society has shown signs of institutional sclerosis," says economist Mancur L. Olson Jr. of the University of Maryland. Special interests multiply as business cartels and labor unions gain power. Needless regulations and laws pile up to protect these interests, and the inevitable result is a misallocation of resources and slower growth, Olson argues. "We're dying a death by 1,000 cuts."

Institutional barriers can impede the adoption of new technology—at huge cost to entire nations. Argentina, a stellar economic performer early this century, now struggles as a developing nation. The worldwide depression of the 1930s was outside Argentina's control, but the long rule of Juan Peron may have done its economy even more harm, Olson argues. Fierce economic nationalism and rampant cartelization of business and labor replaced a relatively open, free-trading economy.

By the same token, the yoke of institutional restraints can be thrown off. Typically, wars or revolutions have done the trick, though there are better ways to cure slow growth. In the mid-1800s, as Britain's industrial revolution was taking off, steps were taken that opened up the economy and set the stage for truly sustained growth. The Corn Laws, which had imposed heavy tariffs on grain imports, and the Navigation Acts, which prohibited the use of foreign ships for trade, were repealed.

BIG JOLTS. In the U. S., Britain, and Western Europe today, a process of reevaluation is slowly beginning. The rigidities that Olson cites as impediments to growth are being questioned, and slowly some changes are being made. Whether they will be an unalloyed success in spurring growth is arguable. The pros and cons of deregulation, tax reform, and corporate restructuring in the U. S. are still being debated.

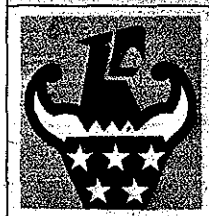
Perhaps the U. S., with so successful an overall economic history, may simply be unaccustomed to making the adjustments that changing circumstances warrant. Historically, it takes a big jolt to the system, such as the Great Crash of 1929 and the ensuing Depression, to create an upheaval and reorder economic priorities. The U. S. economy is being shaken up again—by the ever-growing trade deficits. If irreversible decline is to be avoided, the U. S. needs to create a new framework for growth. When it does, the still-vigorous inventiveness of America can be properly harnessed, and economic maturity need not be a euphemism for senescence.

By Karen Pennar in New York

PATRICE CAIRE

NO PAIN, NO GAIN: HOW AMERICA CAN GROW AGAIN

The steps the U.S. will have to take to regain its competitive edge



The U.S. isn't the only country that can't seem to grow as fast as it used to. Japan, West Germany, and other leading industrial nations also have slipped from their robust growth rates of past years. And their productivity gains have dropped, though they still exceed those of the U.S.

The result is that the so-called mature economies are now locked in a competitive struggle for each other's markets while the new trade tigers, such as South Korea and Taiwan, make increasing inroads on their old industrial mentors. Instead of seeking new sources of growth, the U.S. and its rivals are stumbling into the kind of rampant protectionism that deepened the Depression.

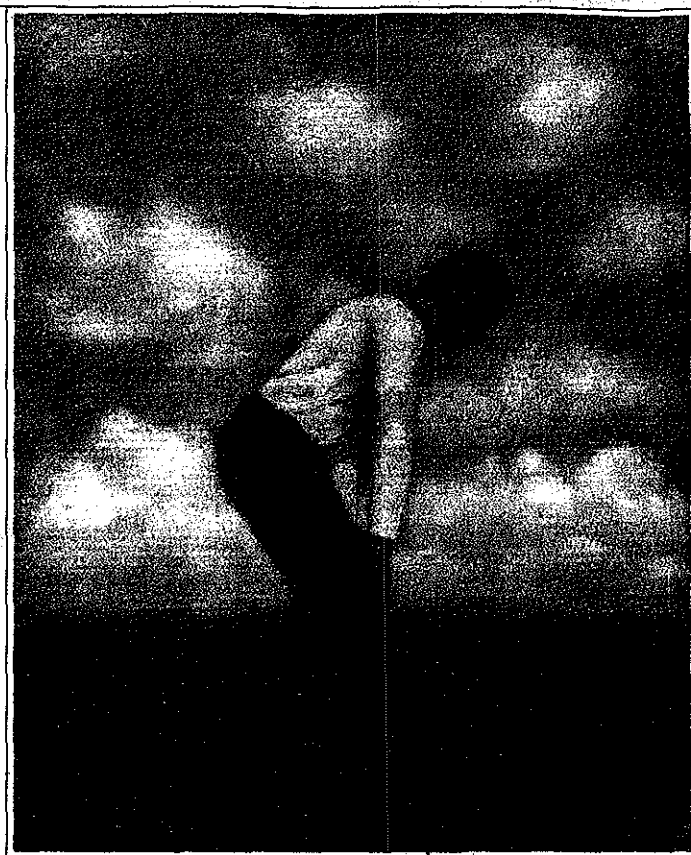
Today, entire regions of the U.S. have been blighted by plant closings, and profits everywhere have been battered by foreign competition. At different stages of the growth cycle, labor may fall behind as rising profits are used to build or modernize capital stock. The profit share may, in turn, be shorted when labor plays catch-up. But both sides are losing because U.S. competitiveness and growth have declined.

The first question is not how to distribute the fruits of growth but how to distribute the pain of not growing fast enough. The second question is how to start growing faster to minimize the cost of past mistakes. For Japan and Germany, the solutions are almost pleasant: What they have to do is grow faster and enjoy a better standard of living by stimulating their economies instead of relying so heavily on trade. For the U.S., however, pain will precede the gain.

MAKING SACRIFICES. To deal with its international debt, the U.S. will have to make some sacrifices. It will have to stop relying on foreigners' savings to finance federal and private deficit spending. If the U.S. had used the imported capital in recent years primarily for capital investment, as the nation did when it was a debtor in the 19th century, there would be little problem now. But it has been used instead to make up the gap between consumption and output, in effect paying for imported cars, VCRs, and the Strategic Defense Initiative.

This is the kind of spending that Washington would have to cut if the politicians were serious in proclaiming that America must again live within its means. There is not much more to be chopped from social programs. But whatever the choice, talk of competitiveness is nothing but talk if the U.S. doesn't move to reduce the deficit and increase national savings. If there is anything that everyone agrees on it is that the U.S. must invest more. To invest it must save. And to save it must consume less now. This gets back to the basics of growth theory. To Paul A. Samuelson of Massachusetts Institute of Technology, a pioneer in the field, "the primary way for a society to grow and improve its standard of living is capital formation and technological progress."

That, of course, is still the big picture. But the gods of growth dwell in the details. A new generation of economists and political scientists is now focusing on ways to bridge the gap between the macroeconomic issues of saving and investment and the microproblems of productivity. This requires a new emphasis on flexibility not only in management and manufacturing but also in how to think about growth.



BUSINESS WEEK's editors have compiled a list of proposals to revive growth and competitiveness reflecting this thinking:

■ **Trade.** Democrats should dump proposals for automatic retaliation against foreign countries that run chronic surpluses with the U.S. and go back to John Maynard Keynes for an idea that could help the U.S. and other countries much more. Keynes once proposed having the International Monetary Fund tax countries that depress domestic consumption to keep pumping up exports. He urged that the revenues be used to finance loans to developing nations on the condition that they join in agreements to avoid world commodity gluts.

■ **Third World debt.** It is, in any event, time for a new Marshall Plan, financed by the industrial nations, to help the developing nations out of their debt mess, conditional on sensible domestic policies. The U.S., Japan, and the other main players are writing off markets of more than a billion people who simply can't afford their goods. Open those markets and the demand side of the growth problem could be solved.

■ **Reciprocity.** Retaliatory tariffs can lead to more of the same by U.S. trade partners and could further impede the U.S.

ILLUSTRATIONS BY MARK PENBERTHY

export sector. However, the U. S. must insist that the Japanese and others play fairly and drop their barriers to American goods and services. The U. S. also may have to treat high tech as an infant industry. American companies must learn to turn their ideas into products much faster to keep foreign concerns from skimming off all the cream of innovation. But the newest technology may need tariff protection at least to assure that research and development costs can be recovered.

■ **Tax policy.** Given the stubbornness of the budget problem, it may not be possible to leave the new tax code alone. But rate cuts for individuals could be preserved by expanding present excise taxes or tacking a consumption tax onto the system. A value-added tax, a levy collected at each stage of production and distribution, is a standby proposal whose time may yet come if it can be designed not to clobber low-income workers. Energy taxes are another good bet, with the same proviso.

With new revenue sources, the government would have the money to finance a better health care system, cut the deficit, or reduce corporate taxes to spur capital spending directly.

■ **Productivity.** Neither Washington nor any number of commissions can mandate a rise in output per hour—and its quality. That can only be done by companies that work with labor to develop such innovative production approaches as flexible manufacturing. Paper entrepreneurialism, the juggling of financial assets by legions of MBAs and lawyers, must be replaced by a new commitment to keeping manufacturing in America. To do that, business must invest in production methods that can respond to rapidly changing markets. Running away from high wages makes no sense when labor costs are being cut to less than 10% of the total production cost.

Business already spends billions of dollars a year on employee training, but it will have to shell out more to get workers with skills to match the new flexible production technology. Government must help by expanding its training and job-search services. Managers have to change their ideas about work organization to handle processes that are more like craft methods than mass production. Labor must become more adaptable to participate as shop-floor managers of machines rather than as cogs in the assembly line.

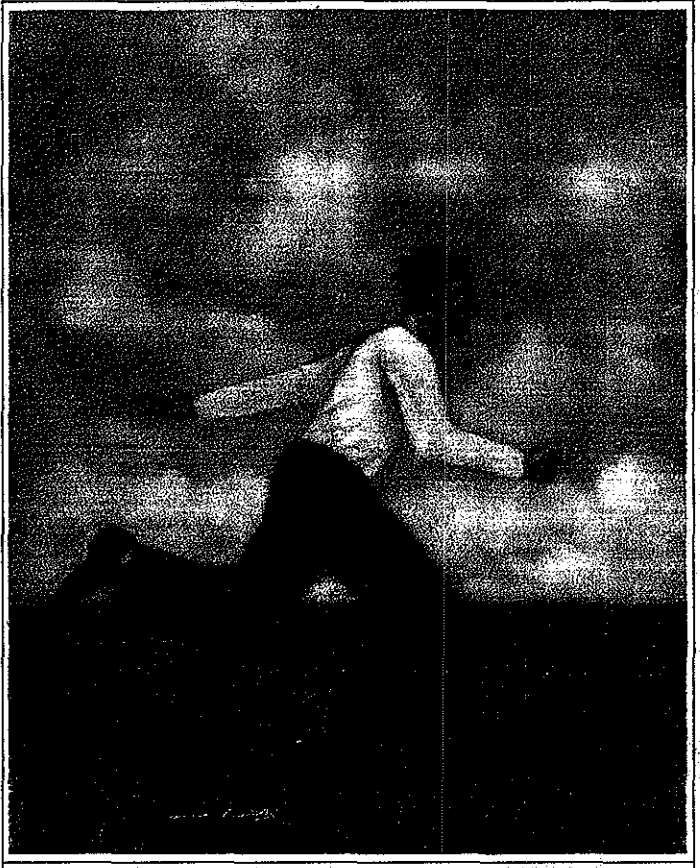
■ **Job security.** It may take federal or state legislation, but companies should give more advance notice of plant closings than they now do, and they should help in the retraining and relocation of displaced workers. If labor is to share in the risks of revamping the industrial system, it needs some insurance.

Economist Pat Choate of TRW Inc. proposes that the kind of workers needed in a "high-flex society" will also need the protection of "portable pension plans," administered by the government, so they can move from job to job without losing retirement benefits. Choate also calls for creation of individual training accounts, an IRA-like fund financed jointly by workers and employers, to pay for a voucher-based retraining and relocation system. Others have proposed new profit-sharing approaches to reinforce worker loyalty.

■ **Education.** The U. S. can boast that 50% of high school graduates go on to college, but only 70% of students complete high school, in contrast to 98% in Japan. The result, says MIT's Lester C. Thurow, is that "their bottom half is beating our bottom half" by being better prepared for the modern work world. Washington should be increasing support for education rather than trying to cut it.

On the college level, the U. S. is doing much better, but it's in danger of slipping. Universities are not turning out enough scientists and engineers to meet new demand in the leading-edge areas of high technology or advanced production systems, and soon may face a shortage of applicants to replace their aging generation of top-quality teachers in these fields. Nor are they encouraging the study of manufacturing. Behind the brain drain is the flight of top students into the more lucrative finance and legal professions. This is partly a matter of culture and values, but may also have something to do with the way business rewards and promotes its engineers and factory managers. Neal Orkin, a legal studies teacher at Drexel University, notes, for example, that U. S. companies "are years behind Japan and Germany in making sure employees share in earnings from patents they come up with."

■ **Technology.** Although collaboration by universities, business, and the government has worked well in the past to spur U. S. R&D efforts, an increasing share of that output is taken by the Pentagon and projects like the President's SDI. Experts insist that such tightly targeted research no longer has the much-acclaimed "spillover" benefits that advocates used to cite. Since the Japanese and other U. S. trade rivals do not have comparable defense burdens, their R&D spending is targeted more toward product and process development in such high-potential areas as biotechnology and superconductivity.



Increasing National Science Foundation funding for basic research could help, but pulling back the Pentagon's claim on the R&D infrastructure might be even better. Failing that, retired Admiral Bobby R. Inman has suggested that Pentagon research contracts awarded to universities give them more freedom on how to allocate the dollars among basic and applied research and even educating scientists.

All of these proposals aim, in one way or another, at equipping the U. S. to attain the fullest possible flexibility in manufacturing and in helping other industries to respond to the foreign competitive challenge. But more important, they address the need to revitalize and encourage the nation's natural sources of economic growth: its vast pool of creative management talent and its historically productive work force. If Americans can form a consensus on these issues, it may not be too late to reach for new frontiers in growth, competitiveness, and the standard of living.

By Norman Jonas in New York

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SEC. 3031. PROTECTION OF SENSITIVE TECHNICAL INFORMATION

(A) Whenever any contractor makes an invention or discovery to which the Department of Energy has elected or preserved the right to elect ownership at the time of contracting;

(i) for purposes of national security under section 202(a)(ii) of Title 35, United States Code, or (ii) because the invention will be made or conceived in the course of or under a funding agreement described in section 202(a)(iv) of Title 35, United States Code, or (iii) pursuant to sections 2182 and 2189 of Title 42, United States Code in a contract which includes the operation of a Department of Energy laboratory dedicated to the research and development activities of that Department's Naval Nuclear Propulsion Program, nuclear weapons programs, or other atomic energy defense activities,

such invention or discovery shall be or become the property of the Government unless a U.S. contractor requests ownership of such invention or discovery, and the Secretary of Energy does not notify the contractor within six months after the contractor request that exceptional circumstances as defined and implemented under 202(a)(ii) of Title 35, United States Code require Government ownership of the invention or the invention or discovery has been classified in accordance with Federal statutes and implementing regulations or has been designated sensitive technical information as authorized by Federal statutes and implementing regulations. If the Secretary does not so notify the requesting contractor, the contractor shall retain ownership

of the invention or discovery under the contractor ownership provisions of sections 200-206 of Title 35, United States Code. In making a decision under this section, the Secretary shall consider --

(1) whether national security will be compromised; and

(2) whether sensitive technical information (whether classified or unclassified) under the Naval Nuclear Propulsion Program or the nuclear weapons programs or other atomic energy defense activities of the Department of Energy for which dissemination is controlled under Federal statutes and regulations will be released to unauthorized persons.

Government Employee Inventions



By: JOHN H. RAUBITSCHEK*

A number of bills have been introduced during the 99th Congress to stimulate innovation and technology transfer at government laboratories.[1] Since these bills focus on licensing by the government of its patents covering inventions made at the laboratories, it seems appropriate to examine the mechanism by which the government acquires title to these inventions.

Rights in government employee inventions are determined in accordance with Executive Order 10096 and implementing regulations now issued by the Patent and Trademark Office. The Executive Order was signed by President Truman on January 23, 1950, after a three-year investigation by the Department of Justice into government patent practices and policies. Although this investigation concluded in 1947, it took almost three additional years and five draft versions of the Order before it was finally signed.[2] The Department of Defense, which was then responsible for 80 percent of the total number of patents covering employee inventions, did not support the Executive Order for a number of reasons including the negative impact it might have on employees.[3]

The Order established a Government Patents Board (GPB) chaired by a presidential appointee who was required to submit the implementing rules and regulations to the President for approval. The Board consisted of representatives from 10 agencies and acted in an advisory capacity to the chairman. The chairman had a small staff which ranged from 6-16 people, and the overhead of the entire operation was provided by the agencies on the Board. Considerable disagreement developed among the members of the Board over the handling of employee inventions, and legislation was recommended to resolve the problem. In fact, the Board, which had met regularly since its creation, ceased functioning after November 9, 1956.[4] The legislative recommendations were never acted on, and later President Kennedy in Executive Order 10930 abolished the Board on March 24, 1961. The functions of the chairman were transferred to the Secretary of Commerce, who delegated them in turn to the Commissioner of Patents.

The principle implementing procedures issued by the chairman were contained in Administrative Order No. 5, dated April 26, 1951. This was revised slightly in April 1962 and published as Part 300 of Title 37, Code of Federal Regulations. It now appears in Part 100 of Title 37. Additional procedural instructions were provided to the agencies by the chairman on January 10, 1955, which established a numbering system and format for the various reports required by Administrative Order No. 5.[5]

Since the issuance of Executive Order 10096, there has been concern about its constitutionality, because some have felt that the President does not have the power to deprive employees of common-law rights to their inventions.[6] Under common law as analyzed in 1933 by the Supreme Court in *United States v. Dubilier Condenser Corporation*[7], an employee, whether working for the government or in the private sector, retains ownership to his or her inventions absent a written agreement to the contrary, unless he or she was specifically employed or assigned to make the invention. The Court considered that the use of the employer's materials in making the invention results merely in a shop right or royalty-free use of the invention by the employer.

The criteria for determining relative invention rights are set forth in paragraph 1 of the Order, which reads in part (a) as follows:

> The Government *shall obtain* the entire right, title and interest in and to all inventions made by any Government employee
>
> (1) during working hours, *or*
>
> (2) with a contribution by the Government of facilities, equipment, materials funds, *or* information, *or* of time *or* services of other Government employees on official duty, or
>
> (3) which bear a direct relation to *or* are made in consequence of the official duties of the inventor.

(Emphasis supplied.) The use of a disjunctive makes the scope of the Order rather broad, and if the language of the Order is applied literally, it would require the government to take title to most inventions made by the government employees.[8] The Order, however, contains some flexibility and in paragraph 1(b) allows the government, subject to the approval of the chairman, to take only a license where the "contribution" is "insufficient equitably" to justify taking title or where the government has "insufficient interest" in the invention.

The first chairman chose not to apply the Executive Order literally, but rather followed the principles set forth in the *Dubilier* case.[9] This was accomplished by emphasizing the term "insufficient equitably"[10] and interpreting "shall" to be the permissive "may." The chairman reasoned that when Congress and the courts

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The views expressed in this article are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the United States Government.

intended something to be mandatory, the word "must" was used.[11] As an aside, the chairman noted that a strict construction of the Order would be contrary to existing cases and could not be done in the absence of statutory authority.[12] In addition, the chairman interpreted "or" as "and" and required all the criteria to be present in order to justify taking title.[13] Thus, the critical issue in the rights determination became whether or not the invention was directly related to the employee's duties.[14]

The Executive Order has been applied for almost 35 years without apparently any serious problem.[15] There have been few appeals by inventors from the agencies' decisions, which may be an indication of the fairness of the system.[16] However, inventors would not be expected to complain about a practice allowing them to keep rights.[17]

Nevertheless, this author seriously questions whether the present policy should be continued. It seems to be a doubtful practice to interpret a regulation contrary to the normal meaning of its terms, i.e., "shall" to mean "should" and "or" to mean "and." In fact, the Navy recommended in 1961 to change "shall" to "may" when Administrative Order No. 5 was under revision.[18] The proposal, however, was not adopted.

The justification for liberal interpretation because of a concern over the constitutionality of the Executive Order is no longer compelling. In 1976, the Seventh Circuit concluded in *Kaplan v. Corcoran* that the Executive Order was constitutional.[19] This decision was cited with approval in *Heinemann v. United States* by the Claims Court which held that the Executive Order was the "sole avenue" for determining employee invention rights and rejected the plaintiff's common-law argument.[20]

It is possible that some agency patent counsel have used the rights determination process as a mechanism to provide incentive to inventors. This might happen if an inventor is allowed to retain commercial rights and the government receives only a license, based either on "minimal" contribution by the agency to the making of the invention, or in exchange for the government filing a patent application. Thus, the employee/inventor could make money by licensing or selling a patent obtained by the government.[22]

Secondly, the liberal interpretation seems to be inconsistent with the development of the Executive Order, which adopted almost verbatim the Justice Department criteria for determining invention rights,[22] and therefore presumably accepted the recommended policy that government ownership of its employees' inventions will best serve the public interest.[23] In fact, it is generally recognized that the Executive Order was intended to change the status quo.[24] In spite of the liberal interpretation of the Executive Order, assignments increased after the Order was issued.[25] One explanation is that many patent counsel felt bound to make their determinations in accordance with the strict terms and intent of the Order.[26] Such a practice would not be questioned by the Patent and Trademark Office, because determinations to take title are not reviewed unless the inventor appeals. It is surprising that there were few appeals, but many inventors may not have been interested in rights and therefore were willing to execute an assignment without going through a rights determination.[27] This willingness may be influenced by advice given them by agency patent counsel.[28]

If agencies are permitted to interpret the Executive Order either strictly or liberally, it is likely that the application of the Order would vary from agency to agency, and maybe even within an agency. This, of course, would defeat the expressed purpose in the Executive Order to achieve uniformity. Although the high percentage of concurring opinions by the Commissioner evidences a growing uniformity as compared to the period prior to the Order,[29] complete uniformity has not been achieved nor could it be expected.

There is no formal appeal from the Commissioner's decision, which is final as provided by 37 C.F.R. 100.7(d). When an accused infringer questioned the plaintiff's title because it was acquired from a government employee, the court refused to examine the rights determination absent evidence of fraud.[31]

In *Kaplan*[32], jurisdiction in the district court was based on the Administrative Procedure Act and the review was to determine whether the agency decision on rights was supported by "substantial evidence." Although the Seventh Circuit reversed the lower court's holding that Executive Order 10096 was unconstitutional, it was silent on the question of jurisdiction. It is of interest that neither court mentioned the earlier Third Circuit decision of *Zimmerman v. United States*[33] which not only assumed that the Order was constitutional but also held that jurisdiction was in the Claims Court under 28 U.S.C. section 1498(a), which was amended in 1952 to allow a government employee in certain circumstances to bring suit against the U.S. for patent infringement. The Third Circuit noted that there was considerable disagreement on whether the Administrative Procedure Act was jurisdictional. In addition, it stated that the judicial review of a rights determination was *de novo* notwithstanding the finality of the Commissioner's decision.[34]

When the ownership of an employee invention issue was raised in the *Heinemann case, supra*, neither party initially questioned that jurisdiction was in the Claims Court. As far as the scope of review, that court recently determined that it would apply the "substantial evidence" test.[35] This represents an interesting situation because the Claims Court seems to be following *Zimmerman* on jurisdiction and *Kaplan* on scope of review.

At least one author has advanced reasons why the operations under the Executive Order should not be considered subject to the Administrative Procedure Act. For example, it was noted that the general public does not have an opportunity to participate in the determination.[36] Further, neither the decisions of the Commissioner nor a digest is published or widely circulated. An index of decisions was started in the early 1970s by the Patent and Trademark Office, which makes it possible for one to examine, in the Patent and Trademark Office, what prior practice has been. But the decisions themselves are not considered to form a precedent because they are not published and also are very dependent on the facts surrounding the particular invention. This changed to some extent on January 6, 1986, when the Patent and Trademark Office published in Volume 228 of the *U.S. Patent Quarterly* two decisions on appeals by the inventor of agency rights determinations. It is expected that the agencies will consider these decisions as *stare decisis*, especially since the Patent and Trademark Office is citing them in its own opinions.

Although the court in *Zimmerman* felt that 28 U.S.C. section 1498 was relevant in making rights determinations, the Comptroller General ruled that the existence of an implied license for the government under 28 U.S.C. section 1498 is not affected by a rights determination under the Executive Order.[37] The fact that the government may have rights in an employee's invention, apart from the Executive Order, is recognized by the determination that the inventor has all rights "subject to law." The phrase "subject to law" has been interpreted to be a reference to 28 U.S.C. section 1498.[38] The similarity in language between section 1498 and the Executive Order may confuse the issue of government rights. However, if the Executive Order is interpreted to limit the government to a shop right under the theory of *Dubilier*, the two essentially become equivalent.

Since there is no requirement when to make a rights determination, a problem could arise if an inventor, after executing an assignment, requests a rights determination. Under Title 37 of the Code of Fed-

eral Regulations, the inventor is given 30 days to appeal from an adverse decision by the agency. However, if an inventor executes an assignment gratuitously, the agency does not generally make a rights determination. Further, most agencies would be reluctant to determine rights after filing and obtaining a patent, especially if it were licensed. Although there is a problem in authority for a government agency to return rights to the inventor, especially after the assignment has been recorded in the Patent and Trademark Office, the Comptroller General has ruled that an assignment obtained through a mutual mistake is voidable.[39] In addition, a recorded assignment may not be enforced by a court because the inventor was misled by a government attorney into signing it.[40]

With the emphasis placed on the government to license its inventions, agencies may be under pressure to take title more often. However, there is no evidence that this in fact has occurred.[41] In addition, legislation has been passed creating a defensive patent called a Statutory Invention Registration (SIR) which the Department of Defense is expected to use for its military inventions.[42] In order to file for an SIR, the government should have an assignment or at least be entitled to one.

There are several other issues concerning the Executive Order that should be mentioned. One is the meaning of the term "making," which is not defined in either the Executive Order or Title 37 of the Code of Federal Regulations. The Chairman of the Government Patents Board, however, has given some guidance and considered an invention to be "made" when there has been conception as supported by written evidence.[43] The basis for this is not clear, and it represents a different standard from that used with contractor inventions in which the government also acquires rights if the invention was first reduced to practice under the contract. The chairman's definition of "making" may no longer be controlling.[44]

Another problem is determining what constitutes "directly related" which, as previously mentioned, is the critical issue in a rights determination. In testifying before Congress, Captain Robillard, Assistant Chief, Naval Research for Patents, stated that he could relate almost any invention to the employee's duties.[45] In the present practice, reliance is placed on what the inventor's supervisor thinks about the relationship because of first-hand knowledge and objectivity. But this is still a very difficult area because inventions can be looked at very broadly, as suggested by Captain Robillard.

If the claims are available, they are useful in determining the scope of the invention. In fact, it may be appropriate to wait until there are allowed claims before making a rights determination. However, since claims frequently are drafted by the agency patent counsel, the inventor's rights can be affected without his or her realizing it. For example, if the agency patent counsel includes claims only to the embodiment of the invention which relates directly to the job, a different rights determination might result than if a broader invention was claimed covering research performed before government employment, or which does not relate directly to the job. Of course, it becomes a rather confused situation if claims are included which cover some embodiments relating to the job and some which do not. This author does not recommend carving up the claims in a rights determination, but suggests that separate patent applications be prepared assuming that the government is interested in both types of embodiments. If it is subsequently determined that the embodiments are not patentably distinct, then a decision can be made later to combine the cases.

"Legislation has been passed creating a defensive patent called a Statutory Invention Registration (SIR) which the Department of Defense is expected to use for its military inventions."

If a government employee makes an invention with a non-government employee, the rights may also become very confusing. For example, the government may be entitled to an assignment of an undivided interest from its employee which could be licensed or further assigned. Because it is unlikely that a company would be interested in being a licensee or assignee of such an interest, the government's rights would be equivalent to a royalty-free license. However, the owner of the other undivided interest might negotiate for the government's rights.

There are several ways the government might transfer its undivided interest. It could agree not to license any party or to exclusively license its undivided interest.[46] It is not clear that an exclusive license under these circumstances is subject to the government-wide licensing regulations.[47] If the other inventor is an employee of a nonprofit or small business contractor, Public Law 96-517 authorizes but does not require the agency to transfer its rights to the contractor.[48] In any situation, the government should make a rights determination in such a joint invention. Of course, if the government decides that the employee is entitled to commercial rights, the inventor may deal directly with the owner of the other undivided interest.

Conclusion

Either the Executive Order should be revised to reflect more accurately the existing practice or the implementing regulations in Title 37 of the Code of Federal Regulations should be followed more closely by the agencies.[49] Of course, the policy on government employee invention rights could be addressed by statute, thereby putting to rest any lingering concerns over the constitutionality of the Executive Order.

FOOTNOTES

[1]S. 65, H.R. 695, H.R. 1572. H.R. 3773, a revision of H.R. 1572, passed the House unanimously on December 9, 1985. Its counterpart in the Senate is S. 1914.

[2] 3 C.F.R. 292 (1949-53 compilation). For a detailed history of the Executive Order, see Forman, *The Government Patents Board-Determination of Patent Rights in Inventions made by Government Employees*, 35 J. Pat. Off. Soc'y 95, 127 (1953).

[3]Final Report, Part II, Armed Services Patent Policy Review Board 18-26 (1952).

[4]*Patent Practices of the Government Patents Board*, a Preliminary Report of the Subcommittee on Patents, Trademarks, and Copyrights of the Senate Committee on the Judiciary on S. Res. 53, 86th Congress, 1st Sess. (1959), at III.

[5]No record could be found specifically revoking these procedures, so they may still be in effect. However, there is some confusion because a number of the reports such as "8d," "8e," and "8f," required of the agencies by Administrative Order No. 5, are not referred to in the present Title 37 of the C.F.R. and are not now provided by the agencies.

[6]Gerber, *Patents-Inventions by Federal Employees and Contractors-Disposition of Title and Rewards*, 35 J. Pat. Off. Soc'y 426 (1953); Tresansky, *Patent Rights in Federal Employee Inventions*, 67 J. Pat. Off. Soc'y 451 (1985).

[7]289 U.S. 178, 53 S. Ct. 554, 77 L.Ed. 513 (1933).

[8]Finnegan and Pogue, *Federal Employee Invention Rights Time to Legislate*, 55 MICH. L. REV. 918-66 (1957); *also published* in 40 J. PAT. OFF. SOC'Y 252-89, 322-54 (1958).

Through gift, theft and license, our technology is leaking abroad almost as fast as we develop it. So scratch the long-term dream of a U.S. living off exports of high-technology goods and services.

Does anyone really believe in free trade?

By Norman Gall

NEVER MIND if the U.S. loses its manufacturing skills, we'll just import manufactured goods and pay for them by exporting high technology and knowledge-oriented products. Steel in, software out. Autos in, microchips out.

That's a comforting theory held by a lot of people. Is it workable? Increasingly it looks as if it is not workable. The whole concept is being seriously undermined as U.S. innovations in technology are adopted not only by Japan but also by such fast-developing countries as South Korea, Brazil, Taiwan, even India.

While these countries are more than happy to sell us manufactured goods, they closely control their own imports of technology goods they buy from us. Exports of computers and other high-technology products from the U.S. are still huge, but the long-term prospects are in question. In areas of medium technology, mini-computers in particular, developing countries are adapting or stealing U.S. technology or licensing it cheaply to manufacture on their own. Many of the resulting products are flooding right back into the U.S.

The Japanese developed this policy to a fine art: Protect your home market and then, as costs decline with volume, manufacture for export at small marginal cost. A good many developing countries have adopted the Japanese technique.

Against such deliberate manipulation of markets, what avails such a puny weapon as currency devaluation? Whether the dollar is cheap or dear is almost irrelevant. Free trade is something we all believe in until it clashes with what we regard as vital national economic interests.

These are the broad trends. Now meet Touma Makdassi Elias, 41, an engineer born in Aleppo, Syria. Elias has a master's degree in computer science from San Jose State, in Silicon Valley, and a doctorate from the Cranfield Institute of Technology in England. Grounded in European and U.S. technology, Elias is now a Brazilian.



His company, Microtec, is Brazil's first and biggest producer of personal computers. Elias came to São Paulo eight years ago to teach night classes in engineering. In 1982 the Brazilian government banned imports of small computers. Seizing the opportunity, Elias started making the machines in the basement of a supermarket in the industrial suburb of Diadema.

Technology? "We worked from IBM technical manuals," Elias told FORBES. "We had a product on the market by 1983. We started making 20 machines a month. Soon we'll be making 2,400. Now my brother may be joining our firm. He's a graduate of the Sloan School of Management at MIT. He's been managing an investment company in Dubai, in the Persian Gulf, but we need him here. Brazil is one of the world's fastest-growing computer markets."

There you have it in a nutshell: foreigners, some of them U.S.-educated, copying—stealing, to be blunt—U.S. technology and reproducing it with protection from their own governments. An isolated development? No, this is the rule, not the exception, in much of the world. How, under such circumstances, can the U.S. expect to reap the fruits of its own science and technology?

Time was when technology spread slowly. Communications were sluggish and nations went to great lengths to keep technological innovations secret. In northern Italy 300 years ago, stealing or disclosing the secrets of silk-spinning machinery was a crime punishable by death. The machines were reproduced in England by John Lombe only after he spent two years at risky industrial espionage in Italy. At the height of the Industrial Revolution, Britain protected its own supremacy in

textile manufacture through laws banning both exports of machines and emigration of men who knew how to build and run them.

These embargoes on the export of technology were eventually breached. France sent industrial spies to England and paid huge sums to get British mechanics to emigrate. By 1825 there were some 2,000 British technicians on the European continent, building machines and training a new generation of technicians. A young British apprentice, Samuel Slater, memorized the design of the spinning frame and migrated to the U.S. in 1789, later establishing a textile factory in Pawtucket, R.I. So, in the end, the technology became commonplace, but it took decades, and, in the meantime, England was profiting handsomely from its pioneering.

Not so today, when 30% of the students at MIT are foreigners, many destined to return to their native lands and apply what they learn of U.S. technology. What once was forbidden, today is encouraged. Come share our knowledge.

Consider the case of Lisiong Shu Lee, born in Canton, China in 1949, raised in Rio de Janeiro, now product planning manager for SID Informatica, one of Brazil's big three computer companies. Like many leading Brazilian computer technicians, Lee is an engineering graduate of the Brazilian air force's prestigious Aerospace Technical Institute near São Paulo. Born in China, raised in Brazil, educated in the U.S. "When I was only 24," Lee says, "I was sent to the U.S. to debug and officially approve the software for the Landsat satellite surveys devised by Bendix Aerospace." Lee later worked eight years with Digital Equipment's Brazilian subsidiary.

Like Microtec's Elias, Lee had learned most of what he knew from the Americans. In teaching this pair—and tens of thousands like them—U.S. industry and the U.S. academies created potential competitors who knew most of what the Americans had painfully and expensively learned. Theft? No. Technology transfer? Yes.

In Brazil over the past few years, the Syrian-born, U.S.-educated Elias played cat-and-mouse with lawyers representing IBM and Microsoft over complaints that Microtec and other Brazilian personal computer makers have been plagiarizing IBM's BIOS microcode and Microsoft's MS-DOS operational software used in the IBM PC. The case was settled out of court. Brazilian manufacturers claimed their products are different enough from the original to withstand accusations of copyright theft.

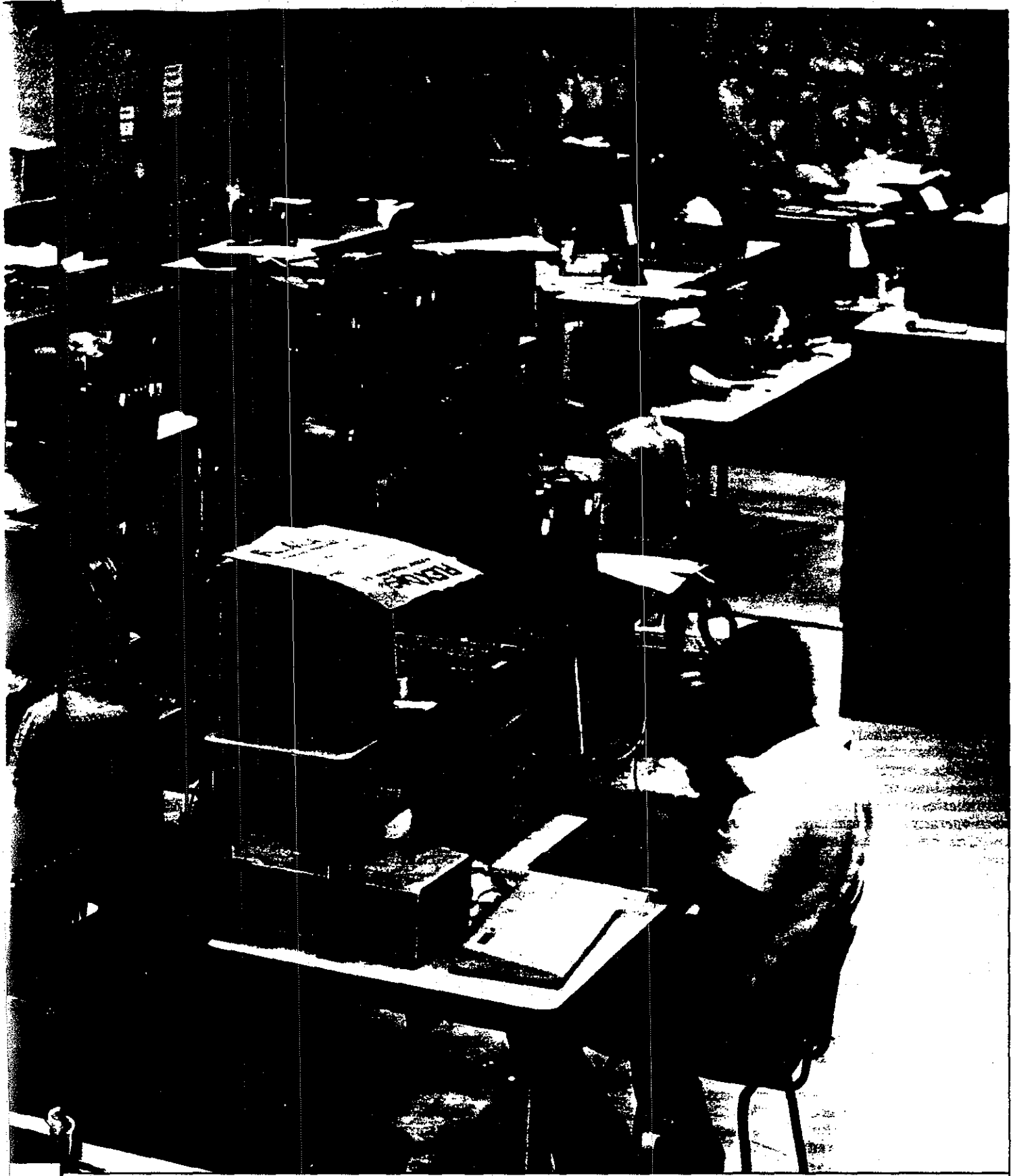
Where theft and copying are not directly involved in the process of technology transfer, developing countries find ways to get U.S. technology on terms that suit them. They get it cheaply. Before President José Sarney departed for his September visit to Washington, the Brazilian government tried to ease diplomatic tensions by announcing approval of IBM's plans to expand the product line of its assembly/test plant near São Paulo. IBM will invest $70 million to develop Brazilian capacity for producing the 5-gigabyte 3380 head disk assembly (HDA).

Ah, but there is a tradeoff involved in the seeming concession by the Brazilians. The tradeoff is that IBM's expansion will greatly improve the technical capabilities of local parts suppliers to make a wider range of more sophisticated products. About a third of the key components in IBM's HDA catalog will be imported, but Brazilian suppliers will get help in providing the rest, some involving fairly advanced technologies.

But does what happens in Brazil matter all that much? Brazil, after all, is a relatively poor country and accounts for a mere $3 billion in the U.S.' $160 billion negative trade balance. Brazil matters very much. For one thing,



Photos by Paulo Fridman/Sygma



Microtec's personal computer factory in São Paulo
Designs cribbed from IBM technical manuals, but different enough to withstand accusations of copyright theft.



Microtec founder Touma Makdassi Elias
From Syria to São Paulo via Silicon Valley.



Newsstand in São Paulo
Plenty of reading choices for computer hackers, too.

what happens there happens in similar ways in other developing countries—and some developed ones as well. Brazil, moreover, is fast adapting to the computer age. The Brazilian computer industry employs over 100,000 people. It includes everything from the gray market of São Paulo's Boca de Lixo district to the highly profitable overseas subsidiaries of IBM and Unisys. Both subsidiaries have been operating in Brazil for more than six decades and, for the time being, have been profiting from Brazil's closed-market policies. It includes many manufacturer/assemblers of micro- and minicomputers and of peripherals. Companies also are appearing that supply such parts as step motors for printers and disk drives, encoders, multilayer circuit boards, high-resolution monitors, plotters and digitizers. The Brazilian market is bristling with new computer publications: two weekly newspapers, ten magazines and special sections of daily newspapers.

Brazil is only a few years into the computer age. Its per capita consumption of microchips works out to only about $1.40 per capita among its 140 million inhabitants, vs. $100 in Japan, $43 in the U.S. and about $6 in South Korea. But given the potential size of the market and Brazil's rapid industrialization, it could one day absorb more personal computers than France or West Germany.

The point is simply this: In their natural zeal to make Brazil a modern nation rather than a drawer of water and hewer of wood, its leaders are determined to develop high-technology industry, whether they must beg, borrow or steal the means. Failing to develop high-technology industry would be to court disaster in a country where millions go hungry. But in doing what they must, the leaders of Brazil and other developing countries run strongly counter to the economic interests of the U.S.

Because of these nationalistic policies, foreign-owned firms are banned from competing in Brazil's personal computer and minicomputer market. Brazil's computer industry is not high tech, if that means being near the cutting edge of worldwide technological advance. But it does show the ability of Brazilian businessmen and technicians to shop for and absorb standard technology, without paying development costs. In computers, where knowledge is the most expensive component, it becomes cheap to manufacture if you get the knowledge free or almost free. The U.S. develops, Brazil copies and applies. There are perhaps a dozen Brazils today.

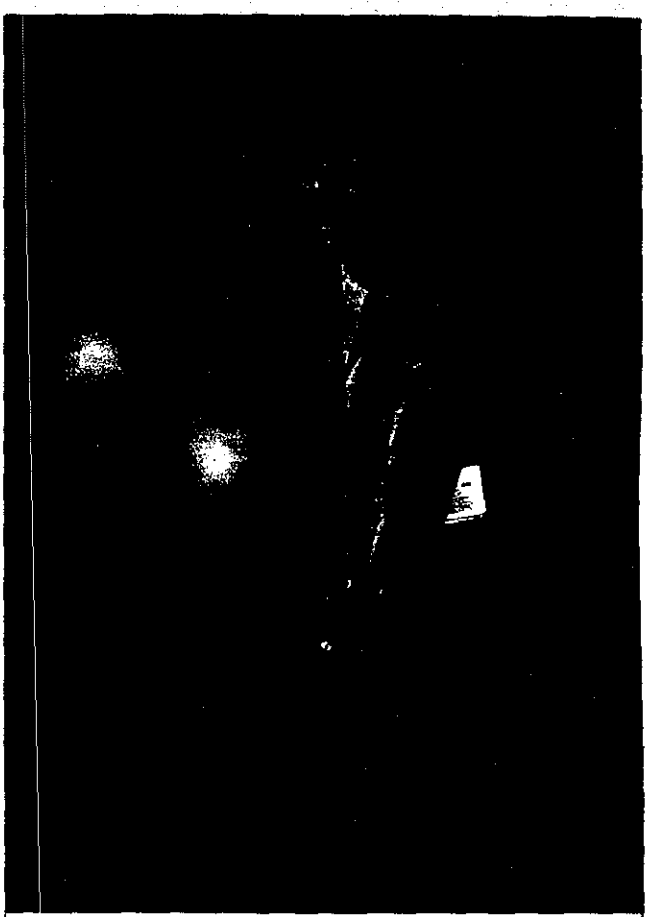
"We're a late entry and can pick the best technology," says Ronald Leal, 36, co-owner of Comicro, a CAD/CAM equipment and consulting firm. "We don't waste money on things that don't work. In 1983 we saw a market here for CAD/CAM done with microcomputers. We shopped around the States and made a deal with T&W Systems, a $10 million California company that has 18% of the U.S. micro CAD/CAM market. T&W helped us a lot. We sent people to train and they came to teach us."

Comicro learned fast. Says Leal: "We developed new software applications that we're now exporting to T&W."

Brazil exporting computer designs to the U.S.? Only five years after IBM began creating a mass market for the personal computer, the U.S. home market is being invaded by foreign products—of which Comicro's are only a tiny part. Technological secrets scarcely exist today.

Aren't the Brazilians and the others simply doing what





Lisiong Shu Lee of SID Informatica
Theft? No. Technology transfer? Yes.

the U.S. did a century and a half ago—protecting its infant industries?

If that were all, the situation might not be so serious for the U.S. But pick up any U.S. newspaper these days and count the advertisements for Asian-made personal computers claiming to be the equivalent of the IBM PC but selling at maybe two-thirds of IBM's price.

According to Dataquest, a market research firm, Asian suppliers will produce nearly 4.5 million personal computers this year. At that rate, they should capture one-third of the world market by next year. Taiwan now is exporting 60,000 personal computer motherboards and systems monthly, 90% of which are IBM-compatible. Of these, 70% go to the U.S. and most of the rest to Europe. Korea, Hong Kong and Singapore together ship another 20,000 each month.

Dataquest says it takes only three weeks after a new U.S.-made product is introduced before it is copied, manufactured and shipped back to the U.S. from Asia.

Thus the U.S. bears the development costs while foreigners try to cream off the market before the development costs can be recouped. That is the big danger. The days when a person could be executed for industrial espionage are gone.

President Reagan recently warned that the U.S. is being victimized by the international theft of American creativity. Too many countries turn a blind eye when their citizens violate patent and copyright laws. In 1985-86 U.S. diplomats successfully pressured Korea, Singapore, Malaysia, Taiwan, Hong Kong and Thailand to pass or at least to draft legislation enforcing patents and copyrights more strictly. Brazil is a major holdout.

The difficulties between Brazil and the U.S. over computers crystallized in the 1984 Informatica law, which Brazil's Congress passed overwhelmingly near the end of two decades of military rule. The law, in effect, legalizes stealing—so long as the victims are U.S. technology exporters. Complains the head of a leading multinational whose business has been curtailed under the new law: "They want our technology but want to kill our operations. This whole show is sponsored by a handful of sharp businessmen with connections in Brasília who are making piles of money from their nationalism."

The new law formally reserved the Brazilian micro- and minicomputer market for wholly owned Brazilian firms. It allowed wholly owned subsidiaries of foreign companies—IBM and Unisys—to continue importing, assembling and selling mainframes, but not out of any sense of fairness. It was simply that Brazilian companies were unable to take over that end of the business.

Under the law, joint ventures with foreign firms were allowed only if Brazilians owned 70% of the stock and had "technological control" and "decision control."

The main instruments for implementing this policy were tax incentives and licensing of imports of foreign hardware and knowhow, all to be approved by the secretariat of information science (SEI).

In 1981 Brazil's then-military government decreed that SEI would control the computer and semiconductor industries and imports of any and all equipment containing chips. The implications are especially ominous for U.S. interests: Brazil's SEI is modeled, quite openly, on Japan's

notorious Ministry of International Trade & Industry (MITI). Brazil's computer policy today follows the line of a mid-Fifties report by MITI's Research Committee on the Computer.

In the 1950s and 1960s MITI used Japan's tight foreign exchange controls to ward off what its nationalist superbureaucrat of the day, Shigeru Sahashi, called "the invasion of American capital." In long and bitter negotiations in the late Fifties, Sahashi told IBM executives: "We will take every measure to obstruct the success of your business unless you license IBM patents to Japanese firms and charge them no more than 5% royalty." In the end, IBM agreed to sell its patents and accept MITI's administrative guidance on how many computers it could market in Japan. How many Japanese products would be sold in the U.S. today if this country had imposed similar demands on the Japanese?

Some U.S. economists are describing the result of the Japanese policy as the "home market effect." They mean that protectionism in the home market tends to create an export capability at low marginal cost.

"Home market protection by one country sharply raises its firms' market share abroad," says MIT's Paul Krugman, reporting the results of computer simulations of international competition in high technology. "Perhaps even more surprising, this export success is not purchased at the expense of domestic consumers. Home market protection lowers the price at home while raising it abroad."

Brazil surely has similar intentions. IBM and other U.S. computer companies are transferring technology to Brazil as never before.

The Brazilians may have grasped a reality that the U.S. has been unable politically to address: that while there is no way to check the fast dissemination of technology today, the real prize in the world economy is a large and viable national market—a market big enough to support economies of scale and economies of specialization. In short, while a country can no longer protect its technology effectively, it can still put a price on access to its market. As owner of the world's largest and most versatile market, the U.S. has unused power.

Taiwan, Korea, Hong Kong and Singapore, lacking large internal markets, could develop only because they had easy and cheap access to the rich U.S. market.

Why doesn't the U.S. reciprocate? The Reagan Administration has threatened to restrict imports of Brazilian exports to the U.S. by Dec. 31 if Brazil doesn't 1) protect software with new copyright legislation, 2) allow more joint ventures with foreign firms, and 3) publish explicit rules curtailing SEI's arbitrary behavior.

But the Brazilians are hardly trembling in their boots. Brazilian officials hint that if Brazilian exports to the U.S. are curbed, Brazil won't be able to earn enough dollars to service its crushing external debt. Diplomats of both countries want to avoid a showdown, so they keep talking. And while they talk, the Brazilians do what they please.

U.S. Customs has responded to manufacturers' complaints by stopping pirated products at the border. But the Taiwanese now have such cost advantages that they can easily afford to license technology that they have already copied. The Koreans are more scrupulous, but pirated technology not reexported to the U.S. is very hard to control.

More than three years ago Edson de Castro, president of Data General, told a Commerce Department panel that foreign nations' computer policies "threaten the structure and future of the U.S. computer industry." De Castro explained why: "U.S. computer companies are reliant on international business and derive a substantial portion of revenues from exports. Because of the rapid pace of technological development, the industry is capital intensive. Growth and development rely heavily on an expanding revenue base. This can only come from full participation in established and developing global markets. Reliance upon domestic markets is not enough."

Yet after resisting the Brazilian government's demands for a decade, de Castro's Data General is selling technology for its Eclipse supermini to Cobra, the ailing government computer company. Other U.S. computer manufacturers are following suit.

Hewlett-Packard, in Brazil since 1967 with a wholly owned subsidiary to import and service the company's products, has just shifted its business into partnership with Iochpe, a Brazilian industrial and finance group. A new firm, Tesis, 100% Brazilian-owned, will make HP calculators and minicomputers under its own brand name.

"Only a few years ago HP refused to enter joint ventures, but now we have ones going in Mexico, China, Brazil and Korea," says a company executive. "In the past we felt, since we owned the technology, why share the profits? Then we found we couldn't get into those foreign markets any other way."

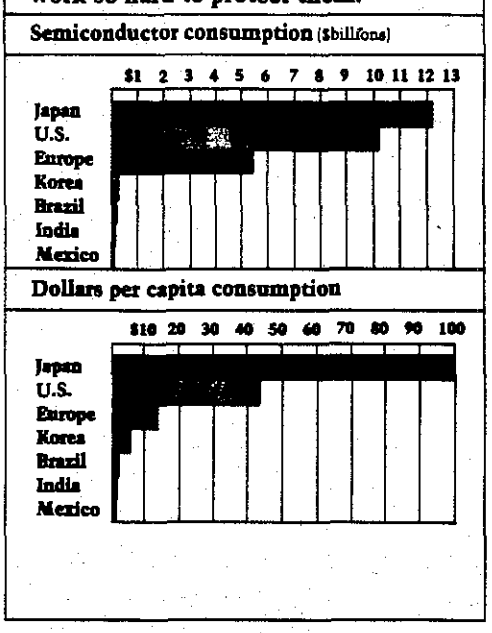
Harvard Professor Emeritus Raymond Vernon, a veteran analyst of international business, says of world technology markets: "Except for highly monopolistic situations, the buyer has a big advantage over the seller. Countries like Brazil and India can control the flow of technology across their borders and then systematically gain by buying technology cheaply."

Vernon draws an ominous parallel: "A century ago the multinationals were in plantation agriculture and electric power. Now they're all gone because their technology and management skills were absorbed by local peoples. The same thing is happening in other fields today, including computers."

This is why it makes little difference whether the dollar is cheap or dear. In this mighty clash between nationalism and free trade, nationalism seems to be winning. Where does this leave the U.S. dream of becoming high-technology supplier to the world? Rudely shattered. ■

Where the chips fall

No matter how you slice it, per capita or by dollar volume, most of the world's semiconductors go to the U.S., Japan and Europe. Don't be misled, though. The smaller markets matter, especially to the governments that work so hard to protect them.



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NewsReview

SERVING AIR FORCE SYSTEMS COMMAND

Labs, inventors 'divvy up' royalties

By JUNE FORTE
AFSC Public Affairs
Andrews AFB, Md.

The Technology Transfer Act of 1986, signed into law by President Reagan Oct. 20, is expected to act as a catalyst in speeding federal laboratory technology into the commercial sector. Because federal inventors will be reaping a 15 percent share of the royalty pie, the new bill may very well spur an era of American inventiveness the likes of which has rarely been witnessed.

The new legislation authorizes the more than 700 federal laboratories to enter into cooperative research agreements with businesses, universities and other organizations.

Although the bill does not specifically prohibit foreign business participation in these joint-research ventures, it is geared toward stimulating the American economy. The Technology Transfer Act also provides for the sharing of licensing revenue between laboratory and inventor. Until Oct. 20, all royalties from patented Air Force inventions went into the Treasury Department coffers.

For Air Force Systems Command laboratories, the new legislation means funds — 85 percent of licensing revenues — earmarked to pursue new research, to support present studies and to pour lifeblood into

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. . . Legislation to spur inventiveness

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projects shelved by budget constraints.

For Systems Command scientists and engineers, the law guarantees them a minimum 15 percent of the take. "Getting the royalties away from the Treasury Department was a four-year struggle," said Frank A. Lukasik, AFSC patent attorney, who has been personally and professionally involved in this legislation since its inception.

In the past, Lukasik said, there hasn't been much action in licensing government-owned inventions. "There's been no champion." With the new bill, the laboratory can license its own inventions. By giving our people a piece of the action, "they can be the champions now," he added.

For purposes of the act, every government location can be considered a laboratory and every federal employee — military and civilian — a potential inventor, he explained.

"Let's say a lab director has something new or novel — say it's an invention — and he or she can't get any further Air Force funds to develop it. The inventor can go out and find a corporation and say 'here's an item that's useful to the Air Force, but it also has a civilian application.' The laboratory now has the authority to accept cash contributions from the business to continue its work in-house or share the work or whatever," Lukasik said.

The word is out, he continued, that the Navy is currently negotiating a license for a laser patent developed by a naval research laboratory inventor. "The Navy will collect $2.5 million, and the inventor is eligible for a $375,000 cash award" — a far cry from the $300 incentive award of the past, which Lukasik said will still be given.

On the Air Force side, the "Two-Dimensional Drawing Board Manikin," an Aeronautical Medical Division (now the Human Systems Division) Human Resources Laboratory invention that was patented in 1977, is also being negotiated for licensing. Although the inventor no longer works for the government, he still will receive 15 percent and the Brooks AFB laboratory will get 85 percent of the royalties, Lukasik said.

AFSC scientists, engineers and other inventors should "dust off their files, dig through their notebooks and check their closets" for applicable inventions, Lukasik urged.

"They can begin by "spreading the word," he advised. But, he cautioned, "Be sure to tell the laboratory director first because there's always a potential for conflict of interest."

Anyone with a patented invention that has commercial application should contact the local Staff Judge Advocate for assistance. For unpatented inventions, work through the AFSC Patent Law Division, AUTOVON 858-5372.