New Greenbacks

How to make a buck—literally

By RICHARD LIPKIN

Suppose you wanted to found a world power. To get the new nation's economy rolling, you'd have to provide its citizens with currency. You'd want to design handsome, durable bills. They must feel substantial and look majestic enough to engender national pride.

On the other hand, this currency can't be costly to produce. It must roll off presses easily, survive its contact with 10,000 sweaty palms, and after years of fingering, crumpling, laundering, and even bleaching, remain recognizable.

"Any scientist who thinks this is a trivial problem is out of his gourd," says Robert R. Shannon, an optics researcher at the University of Arizona, Tucson.

Moreover, the bills must be tough to reproduce. "When it comes to counterfeiting," he adds, "you have to fool some very clever people."

Such considerations represent only the tip of the iceberg for the U.S. Treasury Department's Bureau of Engraving and Printing (BEP), the federal agency responsible for producing the greenbacks that grace U.S. wallets. Faced with the rapid rise of desktop publishing—complete with top-notch ink-jet printers, color copiers, and scanners—BEP has had to confront a sobering reality: Uncle Sam's greenbacks may soon be under siege.

With $380 billion in circulation worldwide, Washington finds itself hard-pressed to keep track of every note. In 1994, the Secret Service seized $45.7 million in counterfeit bills before they entered U.S. circulation—though forgers successfully sneaked $25.3 million in fakes into the economy. Overseas, where counterfeiting of U.S. currency occurs more frequently, agents detected another $137.7 million in bogus bills.

Of the counterfeit notes, 90 percent emerged from conventional printing processes; however, the number of bills produced with the new reprographic technology is growing alarmingly. In 1992, forgers used the new techniques to create an estimated $6 to $8 million in notes—an amount that has doubled every year since 1989.

If the number of forgeries were to continue to increase at this rate until the year 2000, then $1.6 billion in high-tech

Getting less than you paid for

"To counterfeit is death," read a New Jersey banknote during the colonial era. A forged note carried the same warning.

Paper money didn't appear in the British colonies until 1690, when Massachussetts introduced banknotes. By the 1760s, 8 of the 13 colonies were circulating some form of paper money—and forgers quickly followed. Since many colonists could not read or write, even crude forgeries might pass.

In mid-1775, the Continental Congress, desperate to finance the Revolutionary War, added to the confusion by issuing notes backed only by the anticipation of tax revenues. By January 1776, however, a printing press aboard the British ship H.M.S. *Phoenix* had begun turning out fake Continentals, as the currency was called. The combination of dramatic depreciation and widespread counterfeiting soon gave rise to the phrase "not worth a Continental."

Congress recalled the Continental in 1781, and for the next 80 years, the federal government issued no currency as we know it today. Instead, the states chartered private banks to issue currency.

Eventually, some 1,600 private banks issued more than 7,000 varieties of these state notes. Amid the profusion of real notes, counterfeits flourished. By the time the Civil War began, more than one-third of the currency in circulation was fake.

This led Congress in 1861 to authorize a new paper currency. Printed with inexpensive green ink on one side, these greenbacks could not be copied with the cameras of the time. Congress standardized U.S. bills in 1863, incorporating deterrents such as the seal of the Treasury Department, fine-line intaglio printing, and a distinctive paper with embedded red and blue fibers.

In 1865, the treasury established the Secret Service to wage war against forgers. One of the most notorious was William E. Brockway. This New York-based "king of counterfeiting" passed hundreds of thousands of bogus bills between 1850 and 1890. Aided by the recently introduced deterrents, which forced professional forgers to use specialized skills and equipment, the Secret Service suppressed the largest counterfeiting rings, including Brockway's.

U.S. currency has undergone several changes since then. In 1869, the treasury introduced a watermarked paper with bands of dark jute in the substrate. In 1879, it changed the paper to a linen stock containing parallel red and blue silk threads and eliminated the watermark. In 1929, the size of the dollar bill was reduced about 25 percent to save on paper costs, and small, dispersed red and blue fibers replaced the silk threads. Standardizing each denomination's portrait prevented counterfeiters from raising a note's value simply by altering the numbers.

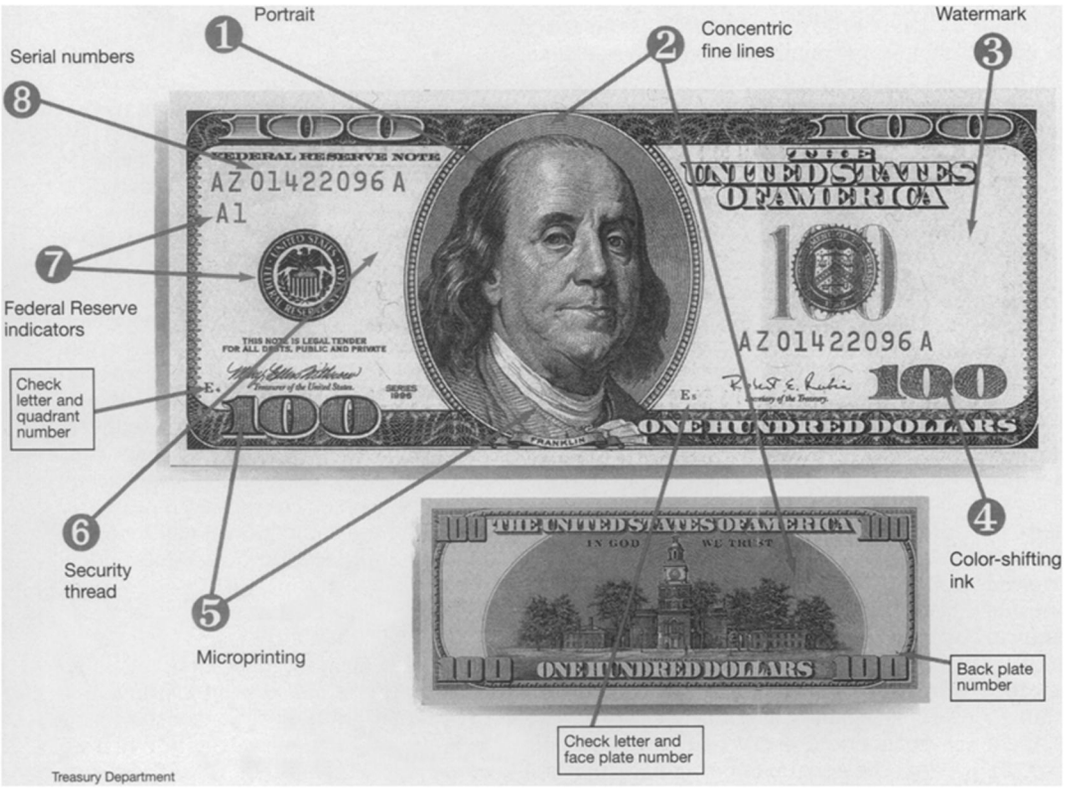
In 1990, two new features appeared: a metallic security thread and a line of microprinting around the portrait. The threat posed today by casual counterfeiters using color copiers has prompted the treasury to suggest several additional changes (see main story).

"There is no single, perfect deterrent," says Thomas A. Ferguson, assistant director of research and development at the Bureau of Engraving and Printing. In fact, "an awful lot of people don't know about the [deterrent] features already in the bill—most of us have never gotten a counterfeit.

"And that's our goal, to keep it that way."

— D. Christensen

The new currency sports several security-enhancing features.



1. An enlarged, off-center portrait of Benjamin Franklin increases recognition, reduces wear, and opens space for a watermark; extra detail stymies duplication.

2. Concentric, fine lines behind the portrait and Independence Hall (on the back) frustrate replication.

3. A watermark of Benjamin Franklin becomes visible only in transmitted light.

4. Numerals printed in color-shifting ink appear green when viewed straight on and black when seen from an angle.

5. The microprinted phrase "USA 100" appears in the lower left numeral 1, while Franklin's coat contains the tiny works "United States of America."

6. A polymer security thread—which glows red in ultraviolet light—runs vertically through the bill, carrying the phrase "USA 100."

7. A new Federal Reserve seal and code indicate the bill's issuing bank.

8. A longer, 11-position serial number contains an extra letter among its letters and digits.

fraudulent currency would pollute the economy, a National Research Council (NRC) committee warns.

Even a casual experimenter—not to mention dedicated professionals—can jaunt over to a computer store, buy an off-the-shelf system, counterfeit money, then throw the equipment away. Such fake notes, agreed scientists on NRC's committee on next-generation currency design, could quickly overwhelm anti-counterfeiting efforts because tracing the bills to their source is "very difficult."

"The quality of the reproduction can be very high," they report, "and not solely dependent on the skill of the counterfeiter." Moreover, because a currency's value hinges on public confidence, a steady trickle of fakes could threaten the dollar's integrity.

That threat has forced a rethinking of U.S. currency.

In 1990, an interagency counterfeit deterrence committee convened to evaluate the integrity of U.S. notes. Since then, a wide variety of potential alterations has gone through testing. Based on the committee's recommendations, the secretary of the treasury decided in July 1994 that U.S. bills need a redesign.

This year, the Federal Reserve will begin circulating a newly designed $100 bill. The note incorporates several safety features whose efficacy federal agents will monitor carefully during the next few years. Ultimately, the treasury plans to redesign U.S. currency at the rate of one denomination per year, moving from the $100 note to the $1 bill.

The potential of desktop counterfeiting has guided the design, materials, and production decisions of the next generation of U.S. currency—and will undoubtedly do so well into the next century. "We want to discourage people from driving to their local copy shop and printing up cash for the weekend," says Shannon. "Yet, at the same time, any security-enhancing feature added to currency must also be acceptable technologically and politically to society.

"This requires a delicate balance."

Although it considered printing the bills on plastics, synthetics, high-tech cloth, and other materials, the interagency committee ultimately advised the treasury to stick with the traditional paper, a blend of 75 percent cotton and 25 percent linen. While less durable than the alternatives—a $1 bill typically survives only about 18 months—this paper has a distinct and identifiable feel that proves not only difficult to copy but helpful in snagging fakes.

"Many counterfeits are still caught when people who handle money say that it just doesn't feel right," says Sara E. Church, a BEP materials scientist. Imitating the texture of money "is not a trivial production problem."

In the intaglio process long used for Uncle Sam's greenbacks, hand-crafted plates that press ink onto paper give each note a distinctive embossed texture. Intaglio images remain crisp for a long time before fading. Moreover, since intaglio requires millions of dollars of machinery and great finesse, the process remains quite difficult to replicate.

"We're asking a lot of this product," Church says. "From a materials standpoint, even surviving the intaglio printing process puts the substrate through a rigorous test. We print 8,000 sheets per hour under enormous pressures, thousands of pounds per square inch. In the end, the currency features must remain recognizable after a lot of abuse."

Multicolored inks, a decorative feature of much European currency, didn't pass muster with the NRC committee. With so many color copiers and ink-jet printers around, extra colors add little extra security to notes, the scientists agreed. In fact, a multicolor forgery can fool the human eye more easily than a monochromatic one.

The NRC scientists nonetheless recommended adding visual subtleties to thwart high-tech printers. In the near term, they suggested introducing inks that change color when viewed from different angles, improving a microprinted thread running vertically through the paper, and employing watermarks, hard-to-copy dot patterns, and moiré patterns, which blur when photocopied.

For the currency of the next century, the scientists suggested some exotic, high-tech features. Plastic and lamination, for example, could enhance the substrate on which money is printed. A note made of three leaves sandwiched together could contain an image visible when viewed with transmitted, but not reflected, light. Designers could also bury shadow images, visible only at certain angles, that could serve as a watermark.

Blending microscopic particles—such as optical fibers, capsules, polymer beads, and radar-reflective dust—into the substrate would deter simple copying and printing and would help in authentication. So would so-called smart inks, whose colors change when viewed from different angles or under unusual light sources—or that appear only in ultraviolet or infrared illumination.

Holograms and diffraction gratings, too, could offer some protection, although desktop graphics systems make them increasingly easy to mimic. In one security test, for example, Bauder reported that he counterfeited an allegedly hard-to-copy hologram in his garage. Kinegrams and pixelgrams, two hologram variants, yield a genuinely distinctive look, though the scientists fear that even they will soon fall prey to home computing.

One of the most provocative means of stymieing counterfeiters involves placing on each bill an encrypted pattern derived mathematically from the bill's unique serial number. This technique would permit bank tellers and shopkeepers to determine a bill's authenticity merely by passing it over a bar-code scanner.

Each banknote would have printed on it a complex pattern, says Bauder, who proposed the idea. Printed alongside the pattern would be a code—an encrypted description of that particular pattern. "To authenticate the note, a scanner would analyze the pattern, look at the numerical code, and compare the two to see if they match." The system would use a public-key encryption process. "This would take counterfeiting completely out of the realm of any kind of copying," Bauder says.

Such bills might prove troublesome on other grounds, however. "The problem with this system," says Shannon, "is that it's too good." Ironically, the same features that could freeze counterfeiters in their tracks are likely to trigger howls of protest against potential federal abuses.

Scanners at every cash register could catch the serial number of each bill as it moves by. In theory, this specificity could enable someone to track and monitor currency transactions. For this reason, the encryption plan will probably fail at the congressional level. "Anonymity during a cash purchase is a tradition people value, for legitimate reasons," Shannon adds.

The present generation of security features, poised to enter circulation in $100 bills, will raise per-note production costs from roughly 3.7 cents to slightly over 4 cents, according to BEP.

The Secret Service will monitor the new features to see how well they deter counterfeiters and increase the capture of fakes.

Scientists engaged in counterfeit deterrence harbor no naive fantasies of a nonreproducible dollar bill. "With enough money, counterfeiters can do anything," says Shannon. "If a group wants to invest $1 million to make phony currency, they can buy intaglio presses and print exactly the same currency as the BEP."

Thus the cat-and-mouse game of production and deception continues indefinitely.

"There's no such thing as perfectly counterfeitproof currency," says Bauder. "Everyone acknowledges that this is an ongoing process of staying a little ahead of the counterfeiters. If we devise a deterrent, the counterfeiters beat it. When we come up with another one, they beat that. It's a never-ending game." □