Inflation isn't only way your money can get smaller

Powerful magnets, dangerous tools use physics to shrink coins

BY JEFF STARCK *COIN WORLD STAFF*

Inflation, it turns out, isn't the only way money can shrink.

Collectors wanting to make a small change to their collection may consider collecting their own "small change," made by shrinking money using giant magnetic fields.

Powerful magnets and dangerous tools, if used the correct way, can shrink coins down to anywhere from 65 to 95 percent of their original diameter, an educational and fun exercise, even if the result is not numismatically valuable.

But, as the famous television commercial disclaimer reads, you should not try this at home.

Bert Hickman, of Stoneridge Engineering, is one of a small number of people who have taken to shrinking coins using what he calls a "quarter shrinker."

His numismatic experiments, as chronicled at his Web site, **www.teslamania.com**, aren't limited to George Washington.

Hickman has shrunken many modern U.S. coin, including the Kennedy half dollar and Sacagawea and Presidential dollars, as well as older U.S. coins like the Indian Head cent, and coins from other nations (Canada, Japan, the United Kingdom).

The process and the result are all proof that "Physics can be fun!" Hickman said.

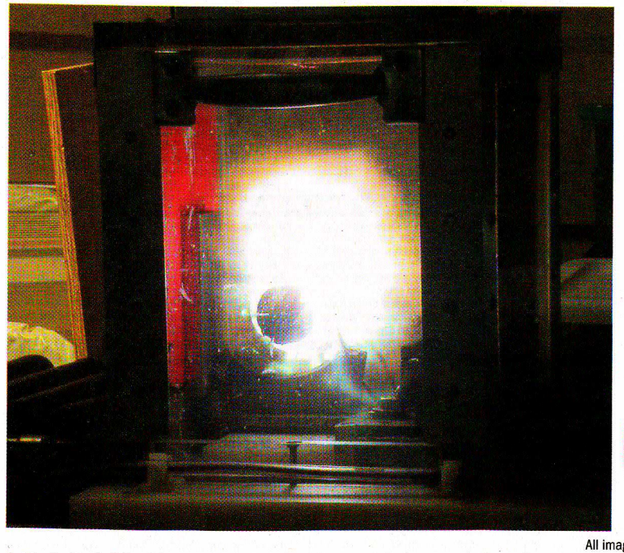
What is the process?

Hickman uses a technique called high-velocity electromagnetic forming (or "magneforming") to shrink coins.

It requires using specialized high voltage devices (called energy discharge capacitors) to slowly accumulate electrical energy and then quickly release this energy into a coil to create the incredibly powerful pulsed magnetic fields that actually do the work of reshaping the metal. The process has been used in metalworking industries since the late 1950s, Hickman said.

Hickman explains the process by noting that most people have witnessed the interplay between two magnets, and how they attract or repel each other.

Although the forces that repel small magnets may appear quite strong, magnetic fields thousands of times stronger can be created by forcing an electric current through an insulated coil of copper wire (the work coil), forming a powerful electromagnet, according to an article Hickman published in *Mint Error News,* spring 2003 issue.



All images courtesy of Bert Hickman and www.teslamania.com.

A blast of a bright, blue-white light and a bang mark the completion of the coin shrinking process, which takes just 50 thousandths of a second. The result of the 6,500-joule blast is a shrunken Kennedy half dollar.

Increasing the current increases the magnetic field, and a really huge current can create an ultra-strong magnetic field that can overcome the "yield strength" of any metal.

The coil is bolted securely to heavy electrical conductors inside a bulletproof blast chamber.

An invisible, but extremely powerful, pulsed magnetic field literally "hammers" the coin with a powerful shock wave, forcing it to change its physical shape in the blink of an eye.

Energy stored within a high voltage capacitor bank is suddenly discharged into the work coil wrapped around the coin.

Up to 100,000 amperes of current is forced through the coil, inducing perhaps as much as 1 million amperes of current to flow within the coin via transformer action.

The current flowing within the coin causes the coin to become a powerful electromagnet as well.

The peak current through the coil for an instant may be comparable to the electrical power consumed by a medium-sized city, according to Hickman.

The rapidly-changing current creates what it called the "skin effect," whereby the immense current flows within a thin circular rind along the outer edge of the coin. The current is confined to a thin outer layer of the coin, penetrating only about 50 thousandths of an inch into the coin, according to Hickman.

The magnetic fields created by the work coil and the circulating current in the coin oppose each other, creating tremendous repulsion forces between them.

The resulting compressive forces on the coin easily overcome its mechanical yield strength, and the coin is evenly "crushed" to a smaller diameter, becoming thicker in the process.

Mechanical yield strength is the scientific term for, essentially, an object's desire to remain as it is.

According to Hickman, when you attempt to reshape a piece of metal, it will resist the attempt, and deforms slightly. At low force levels, the metal will rebound back to its original shape when the force is removed, processes called elastic deformation and rebound.

"However, if you dramatically increase the applied force, the metal will eventually assume a new shape. It effectively 'yields' to the applied force, a process called plastic deformation," Hickman said. "Plastic deformation is used during the many industrial metalworking operations. This includes the coining processes used by the US Mint, and also during coin shrinking."

The shrinking process is all over in instant – about 20 to 25 millionths of a second.

At an energy level of 5,000 Joules, a quarter dollar shrinks to a diameter a bit smaller than a dime, but, amazingly, still retains all of its surface features.

The higher the energy used, the smaller the shrunken coin.

"There's no, 'Honey, I shrunk the kids' magic involved," Hickman said, referencing the 1989 movie.

As the coin shrinks radially, it becomes thicker. A shrunken coin still has the same mass and volume, so its density is unchanged.

A dangerous problem

The coin shrinking process is very dangerous, and Hickman said the small community of active "shrinkers" (engineers and "amateur scientists") is well aware of the risks and is cautious.

Though the coin shrinkers usually acquire key parts from the industrial surplus market and then design and construct their own coin shrinking systems, they share knowledge, safety considerations, and techniques through the Internet.

Every shrunken coin requires a carefully hand-crafted work coil, which is explosively destroyed during the shrinking process.

The same forces that shrink the coin act upon the coil, causing it to explode in a violent and "potentially deadly" shower of copper fragments, Hickman said.

Early in the shrinking process,

Because of their bronze composition, Indian Head cents make suitable candidates for shrinking. Images show a cent before and after shrinking.

the work coil rapidly expands, stretching and ultimately fragmenting from irresistible tensile stresses. The wire's insulation can't stretch to the same degree and is blown off, leaving fragments of stretched, bare wire.

After fragmenting, pieces of the coil are forcefully ejected with the force of a small bomb, Hickman said. For safety, the work coil must be confined within a bulletproof blast shield.

Once the coil disintegrates, residual energy in the system is transformed into a blinding ball of blue-white plasma, accompanied by a loud explosion.

The only thing that remains is the superheated, shrunken coin. Despite it's "explosive birth," Hickman said, the coins amazingly retain their features.

What works, what doesn't?

Hickman cautions that there are several factors affecting how a coin can be shrunken.

"Although the process uses magnetic fields, the coin's electrical conductivity determines how well it will shrink," he said.

Metals that are good electrical conductors, such as copper, silver, aluminum, or gold, work best. Poorer conducting copper-nickel alloys or plated steel coins may shrink only slightly.

While older 90 percent silver coins such as Morgan dollars work very well, coins with only 40 percent silver content may lose surface features due to their lower melting temperature, according to Hickman.

However, all silver coins must be shrunk at reduced energy levels because of their melting point.

The "quarter shrinker" works on most coins, but is particularly effective on copper-nickel clad coins, since these coins use a highly conductive pure copper core sandwiched between thin outer layers of a nickel copper alloy that has a higher melting temperature.

Sacagawea and new Presidential dollars also shrink quite well, since these use a pure copper core sandwiched between layers of a manganese/brass alloy.

Bronze Indian Head and Lincoln cents (1864 to 1909, 1909 to 1942, 1944 to 1962) also shrink well.

Because post-1982 Lincoln cents have a thin copper layer plated over an easily melted zinc core, it is not a candidate for shrinking. During shrinking, the copper layer vaporizes, and the coin does not survive.

"They simply explode in a shower of molten zinc droplets!" according to Hickman.

Because their alloy is harder, and of a lower electrical conductivity, United States 5-cent coins and similar copper-nickel coins only shrink down to about 90 percent of their original size, while pure nickel coins (such as pre-1995 Canadian quarters and 1955 to 1981 5-cent coins) shrink quite nicely. Some nickel-containing coins may also exhibit slight surface roughening after shrinking, Hickman said.

Recent Canadian 25-cent coins made from nickel-plated steel only shrink about 1 percent due to their poor electrical conductivity.

Due to its smaller size, a United States 10-cent coin takes significantly less energy to shrink.

Features on a Roosevelt dime shrunk by 6,000 joules are dramatically different.

Roosevelt ages 30 years, develops a long nose and grows a "Jay Leno" chin. At higher voltages, the coin's edges begin to melt.

For a variety of reasons, older silver 10-cent coins simply shatter at

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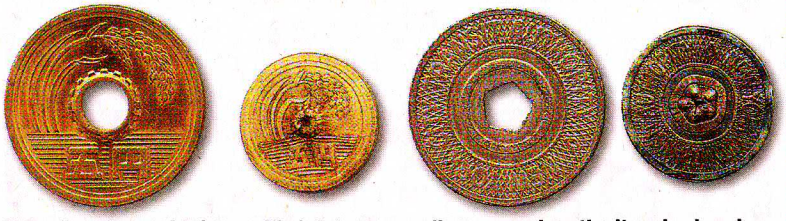
The smaller the coin, the less "juice" is needed to shrink it. Use too much for a Roosevelt dime and Roosevelt ages 30 years, develops a long nose and grows a "Jay Leno" chin, according to shrinker Bart Hickman.



Holes in coins and tokens will shrink or even disappear when the item is shrunk.

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energy levels above 2,500 joules.

Ringed bimetallic coins, with rings and circular centers made from different alloys, often show different degrees of shrinkage based upon the electrical conductivity and hardness of the different alloys. In some cases, the center portion may even become separated from the outer ring.

Shrinking a coin with a hole in the center can reduce the hole or even close it up completely.

Hickman said the process requires a coin that is round or scalloped, but that hasn't stopped a few shrinkers from trying items of other shapes.

At his Web site, Hickman shows a square brass coal token shrunk by Peter Ledlie in New Mexico.

Greater shrinkage in the flat section of the token was not anticipated beforehand, he said.

Shrinking a square aluminum tax token from Illinois resulted in a strange star- or jack-shaped object. Despite the distortion, the lettering can still be recognized on the shrunken tokens.

Surface, finish are factors

Surface features and a coin's finish also affect the finished result when shrinking a coin.

Higher surface features on some coins can create internal force imbalances during the shrinking process. For example, the imbalances cause Kennedy's bust to have a small concave indentation by his left ear and a matching convex projection of the shield on the reverse side.

With pre-1991 Washington quarter dollars and bronze Lincoln cents (1909 to 1942 and 1947 to 1962), the shrinking process tends to push out the portrait, creating a matching concave region on the reverse side of the coin.

(All Lincoln cents from 1909 to 1982, except for the 1943 coins, were made of a copper alloy, either bronze or brass. Bronze, a copper alloy that also includes zinc and tin, was used from 1909 to 1942, and from 1947 to 1962. The amount of tin in the alloy might have been lowered starting in 1947. Tin was dropped in 1942 and from 1944 to 1946, creating the copper alloy called brass.)

The concavity is an inherent property of these coins and is unavoidable, according to Hickman. A sort of indentation is also possible.

The copper center of U.S. copper-nickel clad coins is a much better electrical conductor than the outer copper-nickel layers. This causes the center to shrink a bit more, becoming indented similar to the filling in an Oreo cookie, Hickman said.

Because the coin's features cause slight force imbalances, the coin's rim may also become slightly scalloped.

Other features of the coin can shift, Hickman said, singling out an Anthony dollar. The space between Anthony's chin and her left shoulder and the lettering just to the right of her chin, and the Mint mark, differ between the original and shrunken coin.

"Unfortunately, even shrinking her still doesn't improve her appearance very much," he wrote.

Pure silver or silver alloy coins become slightly discolored (toned) due to the electrical heating that occurs during the shrinking process, which is normal and unavoidable, according to Hickman.

The shrinking process can cause design details of some coins, like the Anthony dollar, to shift.

Coin shrinker Bert Hickman uses dangerous tools to shrink coins (note the warning sign on the equipment). It is not a project for the unskilled.

Sometimes coins will have undetectable impurities that are revealed only when the shrinking process is complete. Trying to shrink this Kentucky quarter dollar didn't work as well as other shrinkings have, but produced a "mutant."

Hickman said only circulating coins should be considered for the small change experiment, because Proof coins turn out "really ugly."

During the shrinking process, coins that previously had mirror-like surfaces acquire a frosted appearance due to microscopic dislocations in the surface of the metal.

Faint lines, known as "Luders lines," can create a halo effect around the subject of the coin. The lines radiate from the center of the coin, reflecting localized plastic deformation during the shrinking process.

Additionally, certain features of a coin may actually shift relative to one another, particularly in clad coins.

The Sacagawea dollar, on the other hand, shows a minimum of feature shifting and Luders lines.

Hickman offers one more cautionary note about the process.

It can sometimes fail to work on a coin that otherwise appears normal because, "Clad coins sometimes contain hidden defects that are not readily apparent," he said. "During the shrinking process, the inner and outer layers may partially detach, resulting in a very strange looking 'mutant coin.'"

When people send in items for Hickman to shrink (he accepts custom orders, or sells shrunken coins from an inventory), Hickman advises people to send one or two spares of each coin so he can fine tune the shrinking process because, "Shrinking is still more of an art than a science."

He won't shrink error coins because the shrinking process relies upon symmetry for balancing forces. "It would also be a shame to further alter rare error coins," he said.

Collecting coins that have been "resized" may stray for the normal numismatic avenues (although many collectors like love tokens, elongated coins and other altered coins), but it could be rewarding, Hickman said.

"I think it is amazing that you can hold a coin that has been 'reminted,' not by hard metal dies, but purely by an irresistible, invisible, and incredibly powerful magnetic field, in less than the blink of an eye!" ■