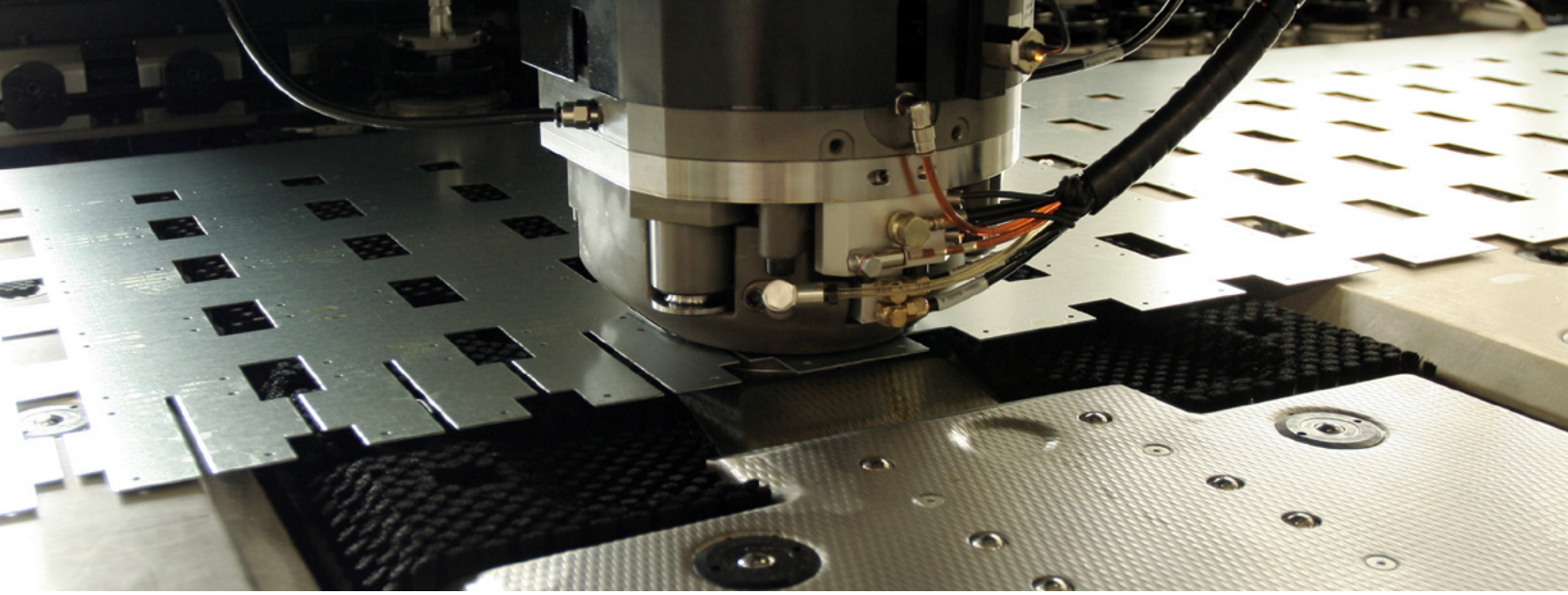
Comparing Metal Fabricating Technologies

A Guide Presented by Conard Corporation

CONARD CORPORATION
Precision Photochemical Manufacturing Since 1965



How Are Metal Parts Fabricated?

There are a number of ways to fabricate metal parts from sheet or strip material. Stamping and CNC punching are mechanical processes that cut the desired parts from metal using hardened steel tools. Plasma and laser cutting use directed energy under computer control to burn through the metal in the desired pattern. Wire EDM uses an electrode carrying high current to do the same thing. Water jets use either pure water or water with abrasive under very high pressure to cut through metal. Photo chemical machining uses acid to dissolve the metal around the resist-protected pattern of the parts.

A Quick View of Key Differences:

Process	Tooling	Set Up	Volume	Process
Stamping	$$$-$$$$$	Physical	Thousands to millions	One strike
CNC Punching	$$-$$$	Physical & Programming	Dozens to thousands	Multi-strike
Etching	$	N/A	Dozens to tens of thousands	Concurrent
Laser/Plasma/ Water Jet	N/A	Programming	Dozens to thousands	Linear
CNC Wire EDM	N/A	Programming	Dozens to hundreds	Linear

Overview of Processes

Stamping utilizes hardened steel dies in the exact shape of the part and creates the part in a single strike of the die. The die costs can run from hundreds to tens of thousands of dollars and may take months to build.

CNC Punching utilizes standard die sets in a variety of configurations under computer control to create various features of a part. It may take a number of automated tool changes and a multiple of strikes to produce the part. Individual dies are generally less than a thousand dollars, but many may be needed. Generally, dies are available in a matter of days to weeks.

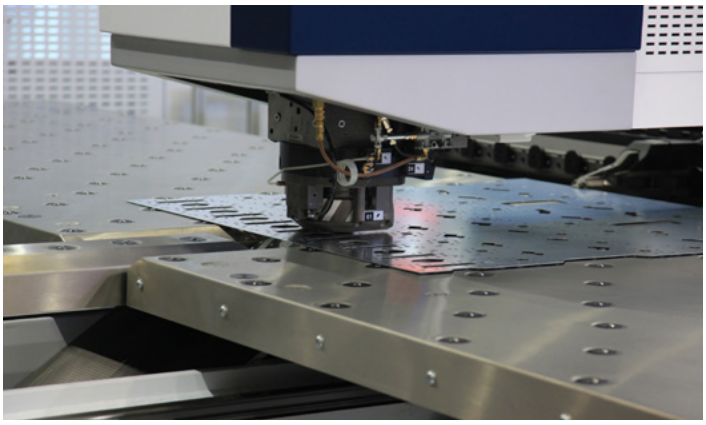


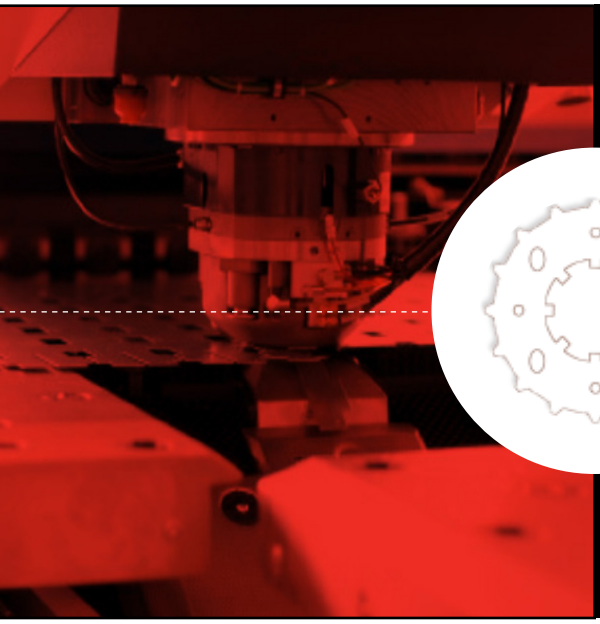
Photo Etching utilizes a film based phototool to transfer the images of the parts on to metal. All of the features of the part are created simultaneously in a single pass through the etching machine. It takes exactly the same amount of time to produce a simple part like a washer as it does to produce a complex part like a screen. Phototools are typically less than $500 and can be created in a day.

Laser and Plasma Cutting utilize guided beams of high-power energy to burn through the metal. The beams trace each feature of a part, just as you would with a pencil. Depending on the material and thickness, typically these devices will cut 200-300 linear inches per minute. The time to produce a part is determined by the complexity of the design. There is no tooling required but the parts must be programmed.

Water jet Cutting iis very similar to laser or plasma; however, the rate is slower and the cutting agent is a high-pressure slurry of water and abrasive.

CNC Wire EDM utilizes a copper wire electrode to burn through metal by arcing an electric current between the electrode and the work object. Typically, multiple layers of metal are clamped together so multiple parts can be cut. This is a relatively slow process, particularly compared to laser and water jet. No tooling is required, but programming is.

Comparison Shopping



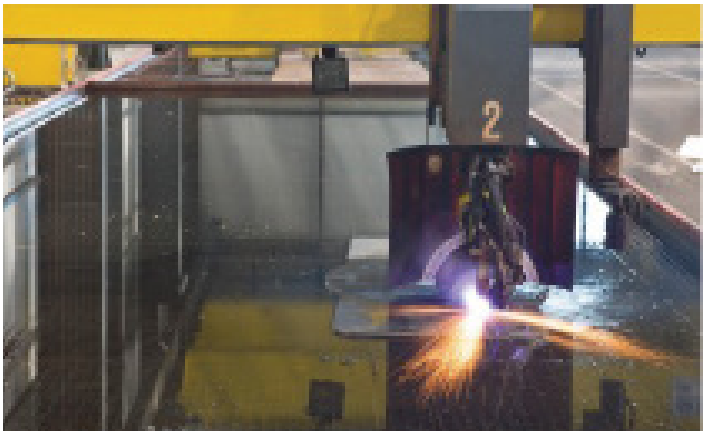
This little part recently starred in Conard's new video about photo etching. "CC Star," as we call it, is 2.7 inches in diameter and is .020" thick stainless steel. Just to satisfy our own curiosity, we asked other types of metal fabricators to quote this part.

The **metal stamping** company quoted about $10,000 to $13,000 to make the hardened steel tooling to produce CC Star. The lead time for the tooling was 6 weeks. The cost of the phototool we would use for etching would be $235. The lead time would be one day. So far, the difference between metal stamping and photo etching is $12,765 and 41 days.

The stamping tool is kind of a big deal. Just the steel, wire EDM service and heat treating for this particular part will run between $6,000 and $9,000. The tool maker figures between 80 and 100 hours of labor for prep and assembly. A die-maker's time is worth $60-$80 per hour. So, a rather strenuous undertaking to produce a smallish metal part.

Once the stamping tool is complete, it needs to be set up in a stamping press. If the stamping house has adopted SMED practices (Single Minute Exchange of Dies), the installation and alignment can be done fairly quickly. It could also be a more involved process.... Once the tool is installed, set up pieces are run and the press is adjusted to produce the parts correctly.

When the stamping press is released for production, they can make about 40 parts per minute....all day long. So, in an 8 hour shift, they can make about 20,000 parts.



Laser, plasma, and water jet cutting are fast, flexible digital solutions for cutting metals and a variety of materials. Lasers use combinations of collimated light and gas to burn a path through material. Plasma uses ionized gas. Water jets use either pure water under very high pressure or a slurry of water and abrasive to scour a path through material. Digital controls guide the cutting beams, which must trace all of the features of the part in a linear fashion as if you were tracing with a pencil. (As a practical matter, the cutting paths are often segmented, but the entire path must be covered.)

The devices do not require hard tooling, but they do require programming, which is a simple matter of software these days. While lasers and plasma are generally faster than waterjets, the actual cutting speeds of these technologies are dependent on a number of factors: type and thickness of material, size and shape of the part, tolerances required, and the power of the equipment itself. In .020" stainless, CC Star might take 2 or so minutes on a waterjet and about 45 seconds on a laser.

Photo etching requires what is sometimes referred to as "soft tooling". Phototools are images of the parts on film. At the beginning, the process of preparing the tooling information is similar to the programming of a laser or waterjet.

To produce the phototool, the designer takes our CAD file and adjusts the dimensions to account for the etching allowance. This "compensated" image is stepped-and-repeated to fill a designated sheet of material. In this case, we chose an 18" x 24" sheet, which allows us to etch 48 parts per sheet. The resulting file is output to a laser photoplotter to produce 2 sheets of film at 8000 dpi resolution. The 2 films are precision aligned and punched for registration. End to end, the process takes about 2 hours, including the plotter time.

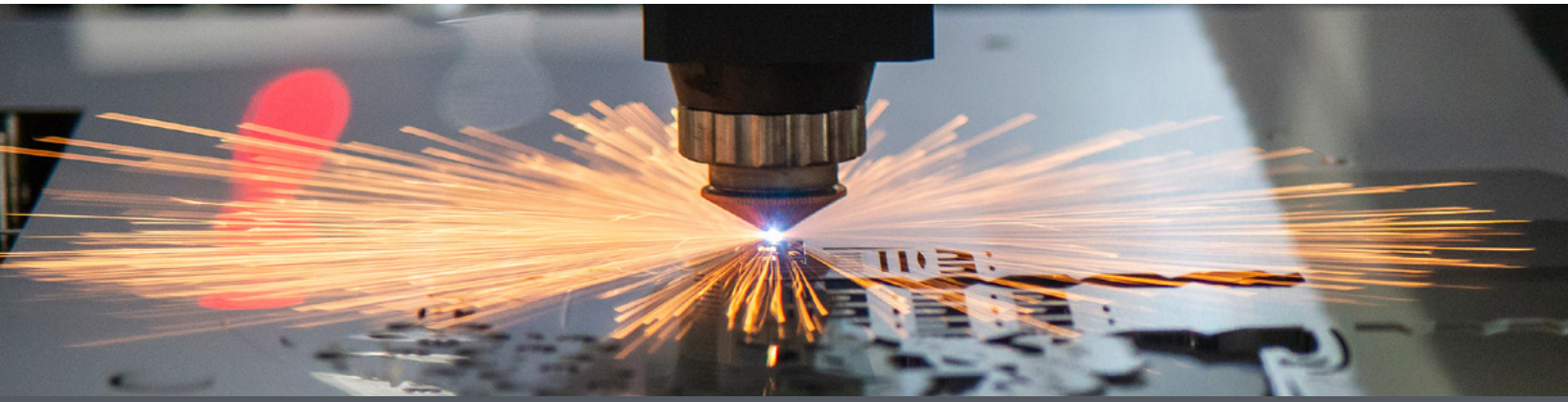
After printing and developing, the metal sheets go into the etching line, one after the other, making about 800-850 parts per hour, regardless of how complex the part is.

Here's The Price Comparison for CC Star Produced in .020" Stainless Steel:

	Photo Etching	Metal Stamping	Laser	Waterjet
Tooling	$<300	$10-$13,000	N/A	N/A
1000	$2.03	$3.85	$2.03	$3.50
5000	$1.96	$1.95		
10000	$1.81	$1.80		

When part geometries are complex, photo etching is the better choice because the rate of production is not affected. If the part had been a simple disk, etching throughput and cost would be exactly the same. For the same size disk, the throughput rates for lasers and waterjets would be faster.

Awareness of laser and water jet cutting is widespread. There are more than 6,000 metal fabricators in the US; the vast majority of which utilize digital cutting technologies. Despite its emergence in the 1950s as means of fabricating metal parts, and long before the digital age, photo chemical etching is still a little known process. There are barely 100 etching companies in the US and only a few hundred in the world. Photo etching is very capable of working with the very thin materials and fine design details that are in growing demand in a range of industries.



Chemical Processes for Fabricating Metal

Photoetching and electroforming are processes to fabricate metal parts. The biggest difference is that photo etching starts with sheets of metal and dissolves metal with acid to make parts. Electroforming starts with a plating bath that contains metal already dissolved in solution and uses electric current to precipitate the metal out of solution onto a conductive pattern or mandrel.

Etching is like carving a sculpture from a block of stone and electroforming is like building a sculpture from Lego blocks.

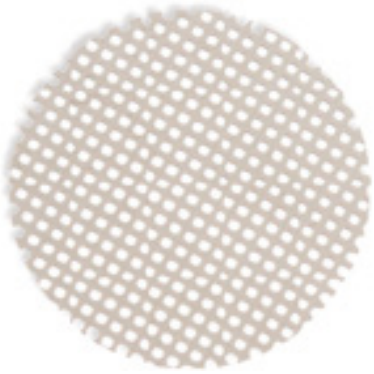
Electroforming can be done with a narrow selection of metals including gold, nickel, copper, palladium, platinum, rhodium and specialized nickel-cobalt and nickel-iron alloys. Electroforming works at the molecular level, and very tiny structures can be created. Meshes and screens with grids as small as .0004" (four ten-thousandths) in width can be produced. Electroforming can also produce parts up to .025" thick.

To produce flat parts, electroforming can use a photoresist like photo etching does to create a deposition pattern on a conductive substrate.

Electroforming can also produce complex 3-dimensional parts. Mandrels, often machined from aluminum, are used to replicate complex miniature structures such as nozzles and bellows. After electro forming, the aluminum mandrels are dissolved in a caustic solution that does not affect the deposited metal.

Despite growing applications for nano-scale devices, electroforming is another rarity in the fabricating industries. There are fewer than 90 companies in the US that perform this unusual process.

Photo chemical etching is applicable to a much wider range of alloys including carbon and stainless steels, aluminum, molybdenum, silver, and most of the widely used alloys of copper and nickel. Thicker materials, including up to .040 in steel, .065 in copper and .080 in aluminum can be chemically etched.



For flat parts in metal thicknesses from .001" and up, photo etching is a fast and cost effective option for making dozens to tens of thousands of parts. Chemical etching is especially effective for parts with

complex geometries or lots of holes (screens, grids, filters.) In the photo etching process, all features of the part emerge simultaneously. So, it doesn't make any difference in time, cost or tooling if the part is as simple as a disk, or riddled with holes like a screen.

Photo etching can make parts as small as .020" diameter and as large as 24" x 60". It's all the same process and all the same equipment.

Other Chemical Processes

MetalPhoto® is the registered trademark for a product and process produced by Horizon Imaging Systems Group. The basis of the technology is silver halide coated aluminum topped by clear anodize Silver halide is a photo sensitive emulsion that was widely used in photographic film, which turns opaque black when exposed to light and developed.

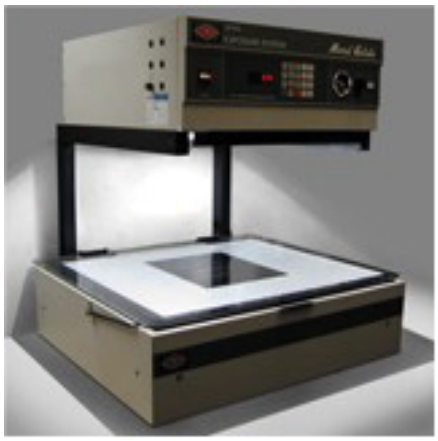


Image Credit: Horizon Imaging Systems Group

The only similarity between MetalPhoto and photo etching is that both processes rely on a phototool as an exposure mask. After exposure, the MetalPhoto plate is processed in a developer/fixer solution and then sealed in another solution. The primary applications for MetalPhoto® are nameplates, metal labels for bar codes, identification, instructions, warnings and so forth. Fabrication of the finished parts by ordinary metal cutting methods occurs after the images have been developed and sealed. **There is no actual chemical etching involved.** The MetalPhoto process is specified under MIL-STD 130N. The process is often used by *nameplate and identification products manufacturers.*

Electropolishing is a process for improving the surface of metal parts using anodic dissolution rather than mechanical polishing.

In electropolishing, the workpiece is connected to the positive output of a DC power supply and submerged in an electrolytic solution. The negative output of the power supply is connected to a sacrificial cathode. The application of DC current causes oxidation at the surface of the workpiece, and especially on burrs and sharp edges where the currentdensity is greatest. The oxidized particles are drawn to the cathode. Electropolishing is often described as the reverse of electroplating.

About Conard Corporation

Conard was founded in 1965 in Glastonbury, CT and has continuously specialized in Photo Chemical Machining (PCM) or chemical etching. The founder, Richard C. Huttinger, was a metallurgist and engineer who had previously worked for both Boeing and Pratt & Whitney. Huttinger developed a process to chemically mill the surface of forged aluminum propeller hubs for Pratt & Whitney. This process was more efficient and cost effective than conventional milling in the days before CNC machining was widely available.

Conard's early expertise in etching aluminum came to the attention of a major aerospace avionics company. Military and commercial avionics systems needed flat aluminum heatsinks to cool printed circuit boards. The heatsinks required detailed cutouts around each component. Photo etching was a cost-saving ideal solution, and flat heatsinks remain a significant part of our business today.

Conard is a Green Circle Award recipient from the Connecticut Department of Environmental Protection for consistently meeting and exceeding our environmental requirements. Conard has achieved registration under the AS9100/ISO9001 standards, in order to assure both existing and new customers that we are qualified to meet your requirements.

Conard has assisted hundreds of companies in developing applications for photo etching. We provide engineering and design support, rapid turnaround of prototypes, and engage in special development projects to help customers solve complex problems.

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