THE SCIENCE AND ART OF METALSHAPING

My experience at Fay Butler's metal shaping seminar.

Metal shaping could be described as a lost art form. Not lost in the annals of time but lost in a present day quagmire of tips, tricks, and "wonder" tools, promoted by a "motley crew" of self- proclaimed metal masters. These masters have put a black veil over their techniques, promising that with this great tool, book, or DVD you too can be an overnight master of metal shaping just like them. There is an element absent from all of these ideas making them worth no more to a true metal shaper than a Chinese finger trap or any other item one might find in a Cracker Barrel gift shop. The missing element from these parlor tricks is science. The laws of nature rationally explained through reproducible testing and results. There is, however, one man who has dedicated his entire life to learning and teaching the science behind physical metallurgy and the art of metal shaping; his name is Fay Butler. Fay has been shaping metal since 1976 in a cattle barn turned workshop that resides within a junkyard in rural Massachusetts. He began hosting his "hands- on, scientific and practical" metal shaping seminar in 1989. The seminar lasts three long days, which start at 8 a.m. and run into the night, often as late as 11 p.m. After learning about the seminar from a past employer I realized I must attend if I wanted to advance my skills in the field of metal shaping.

DAY ONE There are generally three students in the seminar, but there had been a cancellation so it was just myself and RJ Lenz from Daytona, Fla. RJ was a previous acquaintance, as we had both worked on a 1951 Hudson for the television show Search and Restore, and we had both spent time working with long-time Kustomizer Gene Winfield. We started out the seminar with a tour Fay's shop. We were given some history on the vast collection of tools, and a brief explanation of Fay's own journey in the arena of metal shaping. After the introduction, packets on Metallurgy 101 were handed out and it was time get in to the books. We first learned that you can't just jump in to the books; you have to learn the language first. We start at square one answering the question, 'what is a craftsman?' A craftsman is a problem solver who starts with insufficient information and solves from there. How can we solve problems? Through science. Science allows you to form hypotheses and test them. Through these tests you can gain truth and, even when a test doesn't yield the answer you were hoping for, it is still one more piece of information in your quest for truth and you can continue to build from there.

After a thorough discussion about problem solving and critical thinking we move on to the Atom, which is the basic makeup of all elements. This quickly led us to the periodic table. We learned how to decipher its cryptic markings and I really felt the old light bulb come on upstairs. I was learning. You might ask what the periodic table has to do with metal shaping, but understanding the makeup of atoms and the arrangement of the periodic table is very important. As an example, consider alloys. An alloy is a material composed of two or more metals, or a metal and a nonmetal. Alloys are often neighbors of the parent element because of their atomic similarity. So, as we move forth from just the single atom and it's make up, we begin to discuss the way atoms like to arrange themselves in groups. They naturally arrange in what is known as a lattice patterns, which is a geometric packing arrangement. They arrange themselves in such a way in a metal as it changes from liquid to solid. There are seven major groups of these potential patterns, which allows for 21 variations, of which three3 are found universally in metals. As the change occurs the metal starts to solidify, with atoms grouping together into one lattice pattern, then continuing to stack these lattice patterns on lattice patterns, growing in all directions until we have one large, well-organized group of atoms called a crystal structure or grain (Figure 1). These grains, somewhat round in size, range in size from the diameter of a hair to the diameter of a pencil. The craggy area where grains touch each other impedes movement, though movement happens internally in each of these individual grains. The grains have internal defects when growing that occur naturally, like missing atoms or an extra row of atoms. Because of these natural defects metals are nearly one thousand times weaker than originally theorized and so, without these defects, we could not shape metal. Fay established an analogy of people packed in to an auditorium, all-sitting in an organized way to help explain how atoms were arranged in lattice patterns. Returning to the analogy many times to further elaborate on different conditions and defects which made for some great humor and helped to create a mental image of what we were learning.

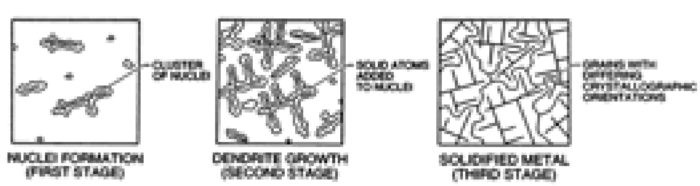
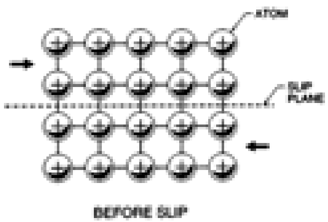
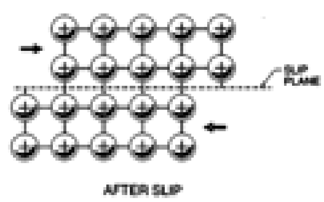


Fig. 1 As metal solidifies atoms pack together and grow dendritically forming a crystalline structure or grain.

We have established that atoms are willing to move under pressure, we will now discuss how atoms in a lattice pattern will move when shaping. To go forward in this discussion though, it is crucial to mention that Fay explains the metal shaping thought process with a dichotomy of form and shape. Form is described as bending the metal in a brake, bending it over your knee, or any change that doesn't change the metal's thickness, where as shape is a matter of changing the thickness of the metal, such as when shrinking or stretching the metal on the power hammer. When shaping you have to constantly decide whether you need more shape, or more form. To change the shape of the metal permanently we must achieve plastic deformation. This is described as working beyond the metal's elastic limit, which is done with a tool such as the power hammer. The power hammer can deliver a 60 to 125 pound blow, as many as 1200 times a minute. This is known as compression, and it is the key term when discussing what the power hammer does. Through compression we can make the metal change its shape permanently. What's happening at the atomic level is that the atoms are slipping along a natural plane and holding that shape. A shallow dent in a door panel is an example of atoms not slipping on these planes. Atoms would much rather move zillions of atoms just a little bit than they would slip along their natural planes. That is why we can generally hammer most of a dent out, it's just form, until we get to a portion of metal that has been stretched; now the problem is shape (the change in thickness). In the area that is stretched, atoms have slipped on a plane and remain permanently moved. This is an example of the type of change we are achieving when shrinking and stretching on the power hammer.





As we approached five o'clock on Monday evening, we took a break for dinner with the promise of firing up the power hammer upon our return. We barely ate anything, anxiously waiting some time on the hammers!. Fay made three separate drawings of hammer patterns he was going to try, and asked us what we thought they would do. On a one-foot square of 19- gauge sheet metal, Fay hammered his patterns. What this demonstrated was that, even if we are changing the thickness of the sheet metal, we were not necessarily developing a compound curve. To develop a compound curve efficiently, first the metal first needs a place to go, then there needs to be a change in thickness, which has an area with lots of change of thickness that progresses to an area with no change of thickness. A smooth surface in compound curve work is due to how evenly this change in thickness, from thick to thin progresses. This quickly showed us that, if we didn't start to understand how the metal was going to react to the compression of the hammer, we would not be able to shape with predictability and things were going to get ugly for our respective projects quickly. However this exercise really got the gears moving upstairs for us and it was now just a matter of making the hand-to-mind connection.

It was now time to start shaping our own projects. I brought the drivers side rear wheel tub from my 1967 Econoline. This was a very basic high crown curve, and was symmetrical to the passenger side. RJ brought a foam buck of a motorcycle tank that he had made at home. To map the shape and highlight lines in these pieces we created a paper pattern, which is a method that Fay learned in the early '80s from Scott Knight, formerly of the now-defunct California Metal Shaping. Using a wide roll, we covered the part with paper and held it in place with small magnets. Where there is shape in the piece we folded a tuck in the paper over itself, holding it down with the magnet, allowing the paper to fit the contours of the part. We begin to see where the panel will need to have "shape" (hammering the metal to change it's thickness), and where it just needs to have "form" (adding a flange, or a detail like an offset). Our paper map showed that the side of the wheel tub was flat and would remain untouched while the transition from the flat side to the top of the tub would require a good deal of shrinking to achieve the 2.5" radius that we had measured on the tub. Fay designed and had Jim Alley of Profile Racing machine a radius gauge that allowed us to accurately measure accurately the radii of our parts, and to gauge the progress of our part as we shaped.

We shrink on both the Yoder Power Hammer and the Pullmax reciprocating machine. We used the same type of dies on each machine, except that the set on the Pullmax are smaller in size and allow you to get in to tighter shapes, like that of RJ's motorcycle tank. The thumbnail or shrinking dies, as they're known, shrink the metal by forming a tuck in the metal as it goes through the machine, locking that tuck in to place and hammering it back down flat as it's pulled out of the machine. This is accomplished with a back and forth motion along the same path, starting from an edge. This is a slow process if you are inexperienced because you have to learn how to control the feed of the panel in to the hammer, keep form in the panel, and, in the case of the Yoder, control the hammer's speed with a foot pedal, all while paying attention to how far in the panel you're shrinking so as not to over-shrink. Over-shrinking is a problem for a beginner that can be overcome by more stretching with the hammer, but it is also a slow process, so it's best to avoid the problem by periodically checking the shape of your panel with a radius gauge and or fitting it to your buck.

After a few hours of hammering with the Yoder, my panel had gone from looking like a distorted bottle cap to resembling the side of a wheel tub for a '67 Econoline. Fay stands by, advising, taking the occasional photograph, and re-enforcing the science he had placed in our heads earlier as we hit stumbling blocks in our shaping. He did step in and help with the shaping a few times by giving the panel a quick run on the machine, showing that the only thing separating us was the science and the knowledge of how to use the machine. When he gave my panel back to me after a few short moments on the hammer I was amazed at how much progress he had made so quickly. Fay's explanation was that he "gets lucky" which was worth a hearty laugh. Fay has an intensity about learning that is second to none, and is self- described as a little edgy at times, but it should be noted that he has a great sense of humor that takes the edge off of trying to learn so much in a short period of time. The dies of the power hammer blurred in front of my face and before you could say metallurgy it was past 10 p.m. and we decided to call it a night, all three of us tired after a long day and two of us feeling a little overwhelmed to say the least. RJ and I retreated back to our rooms at the Antique 1880 Inn, B&B in a neighboring town for some rest. The Inn is recommended by Fay for everyone that takes his seminar and is run by a gracious older couple, Stan and Margaret, who make your stay much more like a visit to your grandparents than a stay at a motel.

DAY TWO We begin our next day at 8 a.m. in the books again discussing steel, iron carbon phase diagrams, elastic limits and the many subcategories they bring with them. We spent time learning about the numbering systems created by AISI, ASTM, and SAE. These numbering systems allow us to further identify metals beyond their basic names to tell us more about their atomic makeup, which allows us to better select materials for specific applications based on their characteristics rather than just blindly asking for steel or aluminum. There are now many numbering systems in place for various trades that detail different aspects of materials. Some trades need to know information like what alloys and how much carbon is present in steels as in the AISI numbering system, whereas some numbering systems only tell of a material's mechanical strength, as in the ASTM numbering system.

Dinner approaches even faster today and once again before we know it we're back on the hammers. I finished shaping my first wheel tub with a little more help from Fay and I was soon started on my second. The first part had come to fruition so quickly that I wasn't convinced I had made it by myself. As I started on my second I was feeling very comfortable at the hammer. It's a very loud machine and it's important to wear gloves, eye protection and very good hearing protection. The sound of two pieces of S7 tool steel hardened to a Rockwell of C56 compressing a piece of 19- gauge sheet metal is something that sounds like it should be coming from a train yard. The rhythm of the hammer is like meditation. There is a oneness at the hammer that I have not felt elsewhere. It demands all of your attention and, if you should afford it such, it will show in your work and, should you not, it will likewise be built directly in to your work. The seminar through my eyes was one-third science, one-third hands-on time at the machines applying the science, and one-third about the psychology of a craftsman. The synopsis being that, if you are not happy with who you are, you could never begin to be happy with the things you are creating; they would just be another mirror of your personal dissatisfaction. It's important to have peace of mind and not let your emotions rule your world. You must be focused on your work to do a good job; this is the essence of caring and from caring comes quality.

DAY THREE On our third day we focused on the evolution of TIG welding power sources, which was a history lesson of greater magnitude than one might imagine. We learned that early home and automobile lamps were an oxygen and acetylene combination but it wasn't until 1895 that French chemist Henry Le Chatelier revealed to the world that equal quantities of acetylene and oxygen in combustion produced a flame far hotter (3300 degrees C) than any gas flame previously known, giving birth to Oxygen/Acetylene torch welding and cutting. The liberty ships of WWII were some of the earliest known welded-hull ships, and were one of the greatest sources of proofs that welding was a reliable method of manufacture and repair. From 1890 until almost half-way through the 20th century TIG welding was in development. This process afforded greater control over the arc than other welding methods, which was needed in the budding aircraft industry for welding metals like aluminum. This required a great deal of refinement of the A/C waveform. TIG machines have gone through three generations of power sources to arrive at the highly adjustable machines we see in the field today.

Fay's wife Phyllis, who made lunch and snacks each day, (and home made muffins each morning!) had everyone for dinner at their home. Phyllis kept us well nourished and a Phyllis- prepared dinner was a delight. After dinner RJ and I were at the machines for our last time of the seminar. I shaped a third wheel tub, and found that my speed at shaping this part had increased quite a bit since I shaped my first. Fay revealed that I had gone backwards in the process on the second part I made because of over-shrinking. I worked on the third piece in greater confidence, making sure to check my part with the radius gauge often to avoid the black cloud that is over-shrinking.

I felt a great deal of comfort at the hammers and, as I mentioned before, it was like meditation. Because I now understood the science of what I was doing, I could predict what would happen to my panel as I shaped it, and because of this I was able to shape with greater precision. The completed batch of wheel tubs in front of me by the end of the third night brought me a great deal of satisfaction as I packed them into a box to ship home. They didn't just represent the repair of my beloved van; they were a milestone in my path as a craftsman,as I realized that much of what I had considered important to metal shaping up to this point had been a falsehood. I left Fay's knowing that true mastery of shaping lay not in a new tool or gimmick, but in the same patient pursuit and application of science that has guided metallurgy for centuries. Our materials and projects may be new, but the knowledge that we seek and the techniques we continue to refine connect us to scientists and craftsmen and the work of centuries.

Story by Matchstick
photos by Fay Butler