Maille Construction in Renaissance Europe

An Essay on the Reproduction of Authentic European Maille

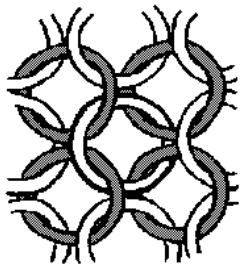
Written by Steaban the Smith

On the field of battle, successful warfare often was determined by the technology one force could bring to bear on the other. Conflicts, undoubtedly, were resolved with "sticks and stones" in prehistoric times. When one group developed a more effective weapon, they would hold a significant advantage over any adversary. Improvements in offensive weapons invariably led to a need to negate and nullify another opponent's advantage. Over the eons armor has evolved to keep pace with the state of the art in weapons. This remains true even today where the "armor" consists of Kevlar helmets and vests, chemical/biological/radiological warfare suites and mechanized infantry (armored vehicles and tanks).

One particularly interesting development in armor technology comes in the form of maille armor. This type of protection is a wonderful amalgamation of innovation and practicality. Economic and technological forces during the medieval and renaissance periods shaped the development of an armor made up of a mesh of rings that could protect a combatant from slashing weapons and even to a small extent from piercing weapons.

The word "mail" is derived through the Old English *mayle*, French *maille*, and Italian *maglia*, from the Latin macula meaning the mesh of a net. Victorian scholars of the 18th and 19th century, however refer to mail as any form of metallic body armor. Francis Grose wrote "*A Treatise on Ancient Armour and Weapons*," in London in 1786. In his writings he describes several types of "mail" and it is clear that he is applying this to several types of armor. He was among the first to use the more general if somewhat less accurate definition. This misuse of the term may be the origination of such inaccurate expressions as "plate mail" and "scale mail" made so popular in science fiction and fantasy novels.

Maille armor is constructed of interlocking metal rings connected in a pattern designed to maintain the integrity of the armor should one or two rings break during combat. In Western Europe a 4 to 1 pattern (meaning that each ring connected to four other rings) was primarily used although there is speculation of an extremely rare 6 to 1 pattern as well. While there are no actual examples of authentic maille using a 6 to 1 pattern, the reality is that a 6 to 1 pattern would have increased the work dramatically without a significant increase in protection.



four rings are linked to the central ring

There is a common belief that European maille was invented by the Celts around 600 BC. Archeological finds of the earliest surviving examples, butted rings made of iron, were

found and dated correspondingly to support this conclusion. The inherent weakness of butted rings was quickly discovered and mitigated by adding alternate rows of solid rings (cut or forge welded) thus increasing the defensive properties of maille. Riveted rings eventually replaced butted rings around 100 AD. This significantly increased the level of protection provided the wearer. It is believed (but not proven) that butted rings were still used for temporary repairs in the field, for non-critical areas and for ceremonial or decorative applications. However, a special split ring resembling a modern key ring has been the method of repair that is documented in archeological finds. These rings were far stronger that butted rings. Brass, Bronze and Copper were considered too soft for use in battle and it is believed that they were only used in ceremonial maille, if at all (much to my dismay and the dismay of many reenactment groups!)

Solid rings alternating with riveted rings appear to be the exclusive method in Western Europe until around 1300 AD, when, maille made entirely of riveted rings began to appear. The primary theory for the change to all riveted construction is accredited to the expense of forging closed rings exceeding that of having apprentices rivet rings. Additionally and unexpectedly the riveted rings appear to have a greater resistance to deformation than forge welded rings. As the availability of larger and larger blooms of high carbon iron and then low carbon steel became available, plates were added to improve on the defense provided by maille. Plate armor became more common and maille was relegated to “filling the gaps”. Some plate armor was fully articulated and required no maille at all. Still maille was still in use by “lesser” combatants throughout the period dominated by plate armor. Eventually, fully articulated plate armor completely replaced maille. However, maille was still in limited use when increasing use of firearms rendered even plate armor obsolete.

In the early days of the maille smith, the armor produced was highly prized. Though as time passed and guilds formed, the making and use of maille garments expanded with, according to Holinshed, maille shirts being part of the common foot soldiers' equipment in 1586 and, according to Edward Davies in 1619, to the equipment of the *arquebussiers*. Because maille armor naturally expanded and contracted, different people of similar size could wear it allowing for a more generic production process.

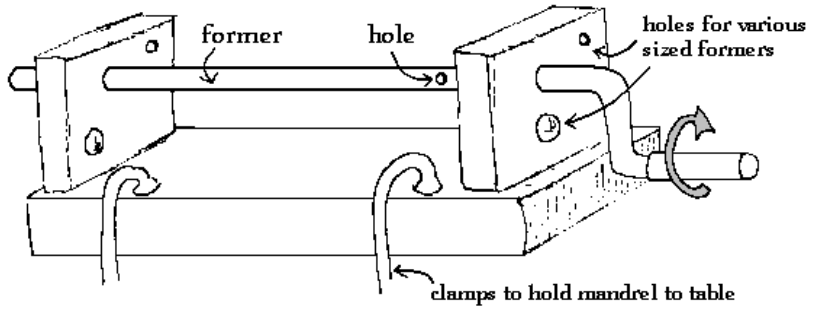
A 15th Century Maille Maker
(Arms and Armour of the Medieval Knight)

Maille had several advantages over previous forms of armor. Maille, with its flexibility of material, allowed movement in combat giving the wearer an advantage over someone in forms such as boiled leather. Maille was relatively lightweight when compared to rigid forms of armor, required relatively little effort to produce and provided good defense against the slashing of edge weapons. However, the blunt force from a solid strike could cause broken bones and internal injuries due the lack of the armors rigidity. Another weakness of maille armor is its vulnerability to thrusts from pointed weapons,

arrows, and crossbow bolts, which could easily split butted rings. Riveted rings of course were significantly more resistant but could still be pierced if the projectile hit with sufficient force. (Note: Modern day tests made by various reenactment groups have demonstrated that a bow fired arrow will punch holes through maille constructed of butted steel rings while maille made with riveted steel rings will resist the same arrow.) Despite these disadvantages, maille armor continued to be used for centuries.

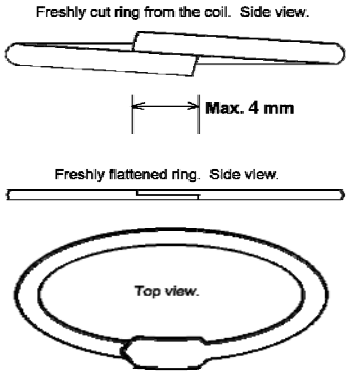
Creation of maille was a long and arduous process. Most of the work was tedious, time consuming and would have been performed by an apprentice under the armor-smith's supervision. The first step in the process of creating riveted maille armor was to draw soft iron into wire form. This was done using forged stock of wrought iron. Wrought iron is almost impossible to obtain today but one can get the same effect using mild steel. Mild steel wire has just slightly higher carbon content than wire drawn from coal-fired wrought iron would have had.

Next an apprentice would wrap the iron wire around an iron rod, or mandrel. The armor-smith would determine the size and had to bear in mind changes in the size of each ring occurring as the maille was constructed. The common belief is that the maille smith would keep numerous mandrels of varying sizes in his workshop. A jig with a handle would accept the mandrel and allow the armor-smith's apprentice to create large amounts of coiled wire quickly and efficiently. The Jig would have a slot or hole to hold one end of the wire while it was wound under tension.



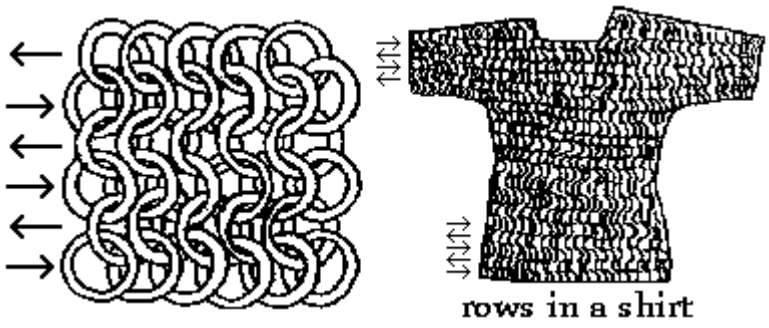
The coils were then cut into individual rings. Cutting was performed using either wire cutters or a cold chisel. (There is no way to know for sure which method was predominant because the flattening process that will come later destroyed any evidence, in the form of tooling marks, that might have been used to determine the exact tool used. Nevertheless, it is likely that both methods were used depending on training and preference.) The rings were then resized so that approximately one third of the length overlapped for the riveting or welding process.

The coiling of the wire and resizing of the rings was done while the metal was cold. Working metal cold was known to cause it to become harder and more brittle. This is known as *work-hardening* the metal. To continue working with the rings it was necessary to soften them by heating them until they were "red hot" and then allow them to cool slowly. This process is called *annealing* the metal.

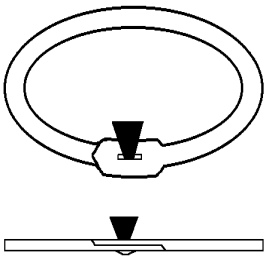


Usually the Master Smith would take over at this point. After annealing the rings the Armor-smith would flatten the rings by placing the rings into a properly prepared swage block and flattening them with a set of dies. The dies were forced together using either a vice like press or with the smiths hammer. The hammer method consisted of a sort of double strike beginning with a light blow to set the overlap, followed by a stronger second strike to flatten the ring. This was a very critical step and would affect the strength and overall appearance of the finished product.

Once flattened, the rings were then punched using a long thin flat tool to create a small slot for the rivet. This was perhaps the most critical step. The slot had to penetrate completely through both ends of the rings, but not beyond. If the slots was too wide the ring would be weakened and have a tendency to split, so it was important to keep the slot width to less than one third of the width of the ring. Again, the Master Smith would usually perform this step.



The rings would then be woven into set patterns. Typically a 4 in 1 pattern was used. Each link would be crimped closed. The rivet was crimped using a tool created for the purpose. It should be noted that the patterns used to create each piece were handed down from master to apprentice. Very rarely would a pattern be altered. Differences in patterns would usually be due to differences in origination points. Tailoring was accomplished by adding or removing rings as individual fit dictated. However, the nature of maille allows for expansion enabling a less than perfect fit to be acceptable. Common opinion is that the average smith needed about one minute per ring to weave and rivet a garment. Since a typical hauberk took about 30,000 rings, it took approximately 500 man hours or about 6 weeks to make one piece.



The next step in the construction of maille garments was the riveting of the rings. The rivet was made out of flattened wire and was, in most cases, iron; though there is some evidence that copper rivets existed. The wire for the rivets was flattened at one end and the wedge-shaped rivets were cut with wire cutters. The rivets were attached one line at a time and crimped into place using a tool created specifically for this purpose. In surviving pieces of authentic maille, the rivet heads all face the

same direction. The commonly held belief is that the armor must have been worn so that the rivet heads faced outward to reduce wear and tear on the *aketon* (the padding worn under the maille) and to reduce discomfort for the wearer.

The final step in the process was to case harden the maille. The armor would be heated in an airtight clay container with powdered charcoal at a dull red heat for several hours. The outside layer of metal in the iron rings absorbs carbon from the powdered charcoal making the rings much harder on the outside but still relatively soft and resilient on the inside. The armor was then quenched in clear water hardening the rings further still. If left in long enough the rings would become hardened steel clear through. However, this was undesirable because the rings would become too brittle for use in combat. A soft central core in each ring was thought to reduce the chances of rings cracking and splitting.

One must use great care when researching the authenticity of maille styles and techniques. There are no surviving contemporary documents on the technical nature of maille armor construction and the only study into the maille making process can be achieved through the studying of surviving artifacts, illustrations of maille smiths at work, and historical documents discussing maille in general There are extremely few scholarly texts on the subject but there are many “History” books that give mention to historically inaccurate material. It is essential that any references used be based on fact and not speculation. For instance: Sir James Mann wrote about elements found in the Sutton Hoo ship-burial site that were thought to contain butted maille fragments. Currently this piece is found in the British Museum in London. This piece is authentic to the period in question and appeared to be constructed of butted rings alternating with forge-welded rings apparently in conflict with the accepted school of thought within the scientific community. Namely, that all period authentic European maille was constructed of either riveted rings or combinations of riveted and cut solid or forge welded rings. There was no conflict, however, had the existence of this piece been taken in context. This maille was buried with King Raedwald. Most historians believed that this armor was constructed specifically for this ceremonial purpose. Since it was not to see combat, it is thought that this piece was deliberately constructed as a costume piece. Thus, perhaps it would be historically accurate to recreate such a piece as long as we explain that it is not intended for combat but only as a ceremonial (burial?) costume. While is seems unlikely this would be common since one would have to be very wealthy indeed to afford a suit of maille constructed simply for show, in this instance the owner was buried with an entire ship.

Nevertheless, the assertions of Sir James Mann were later refuted in the tome "The Sutton Hoo Ship Burial" by Rupert Bruce-Mitford, published by British Museum Publications in 1982. Volume 2 discusses the arms and armor. Chapter 4 discusses the maille coat in great detail. This quote from pp. 236-7 may be of interest in the current discussion:

> "It does, however, clearly show, contrary to previously published statements, that the mail was made of alternate rows of welded or forged links and of ***riveted links***." (*emphasis added*) He explains the "previously

> published statements" in a footnote: "E.g. Sir James Mann, referring to riveting of mail as universal in the west, says 'the only exception in Europe' is the mail shirt found at Sutton Hoo. 'Minute examination has shown that in this case the ends of the rings are merely butted together as in much mail of Oriental origin...'(Mann, in Stenton, 1957, p.62). ... The idea that the Sutton Hoo mail coat was composed of links with butted joints had been formulated by the Research Laboratory as a result of visual examination, and only recent radiography has disclosed the true construction."

Unfortunately several works were published based on the false premise that the Sutton Hoo pieces were composed of butted maille and this has precipitated wide dissemination of this myth.

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