

# LORICA SEGMENTATA CONSTRUCTION

*Advice and tips for first-timers*

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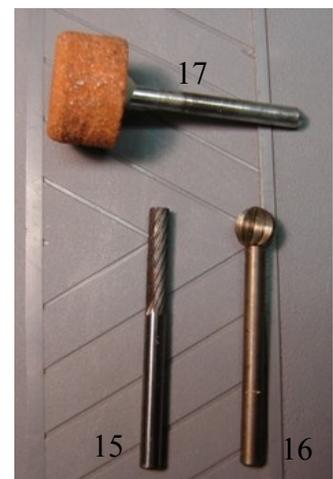
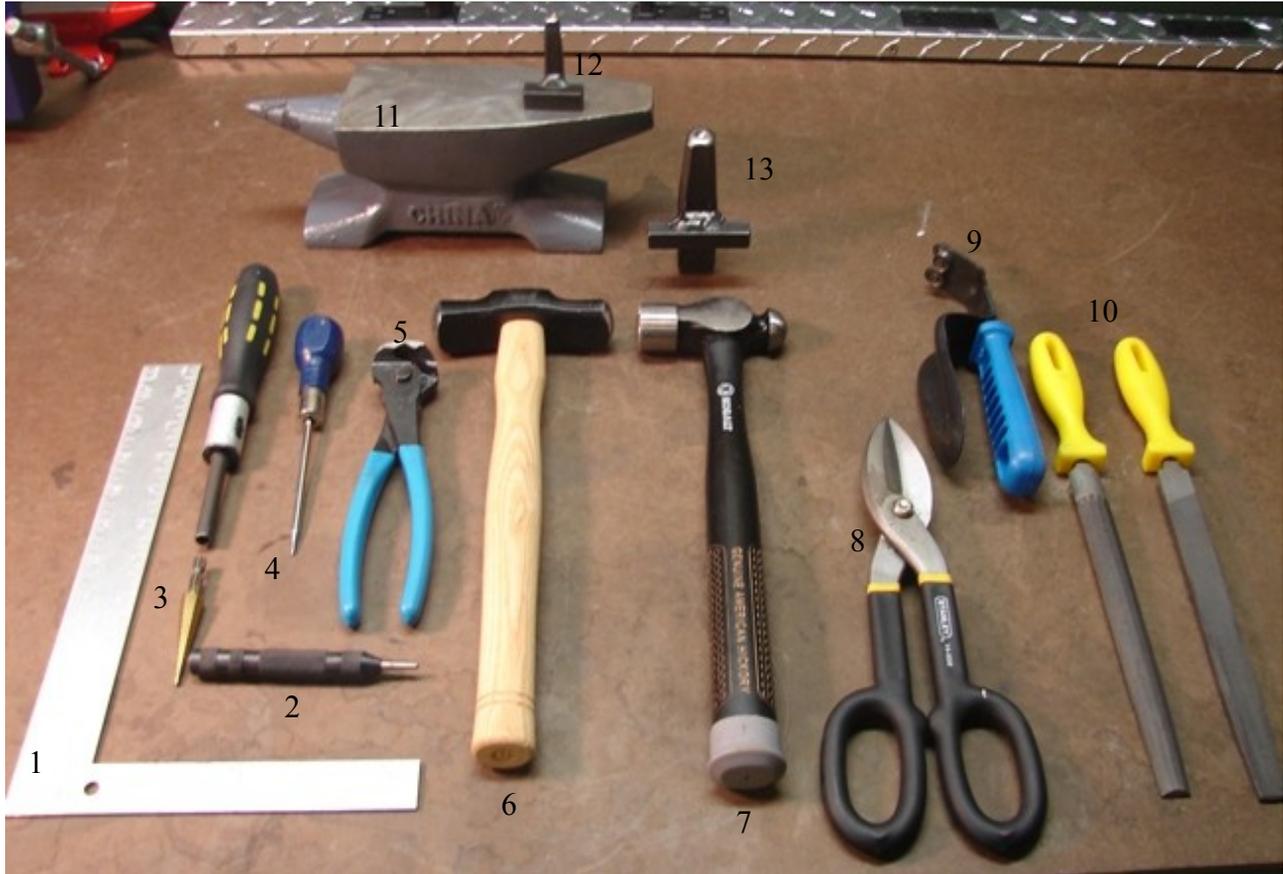
## Preface

This guide is intended to help individuals in constructing their own *lorica segmentata* for the first time. I try assume the reader has very little experience in metal work and give advice on even some of the more basic steps. My intent is to encourage reenactors to construct their own segs, and my hope is that this guide can keep the prospect of constructing one from seeming too daunting or overwhelming. It can be done with only a little skill (that comes with some practice) and patience more than anything else. Much gratitude goes out to Matt Lukes for answering many of my questions and for his superb advice and assistance, to Matt Amt for providing patterns and advice on the Legio XX website and to Edge and Chris from Leg. XI for encouraging me to make my own, even when I thought I wouldn't be able to do it. Though I have a degree in engineering, I am not an expert in armor construction, and this guide is mostly a compilation of the tips and advice I've received from others and some things I figured out for myself. Enjoy!

# Recommended Tools & Materials

## *Metal working tools*

The right tool always make the job easier. The following tools will probably prove to be useful for cutting, drilling, bending and finishing the metal plates.



*Key to the tools in the above figure:*

1	Right angle straight-edge	12	1/8 inch rivet set
2	Spring loaded center punch (for making drill locations)	13	3/16 in. rivet set
3	Drill step bit (for deburring drilled holes)	14	Throatless metal shear
4	Scratch awl (for scribing cut lines)	15	Dremel tungsten-carbide cutting bit
5	Nippers (for cutting rivets down to size)	16	Dremel high speed cutting bit (for rivet removal)
6	Armor raising hammer (for flaring & folding edges)	17	Grinding stone
7	Ball-peen hammer (for riveting)	NP	Vice grip (at least 4.5 in.)
8	Tin snips		55 lb. anvil (or larger)
9	Hand deburring tool (for cleaning cut edges)		Drill press
10	File assortment		Metal yard stick (or a straightedge)
11	15 lb. anvil		Metal punch (if no drill press)

Pictured to the right are some optional hammers to consider, especially if working with 16 gauge sheet steel.

*From left to right:*

Rubber mallet (straightening plates)
Teardrop mallet (for gentle curves)
2-3 lb. rounded face hammers (for very thick plates)
“Swedish” cross-peen (for difficult bends in thick plates)



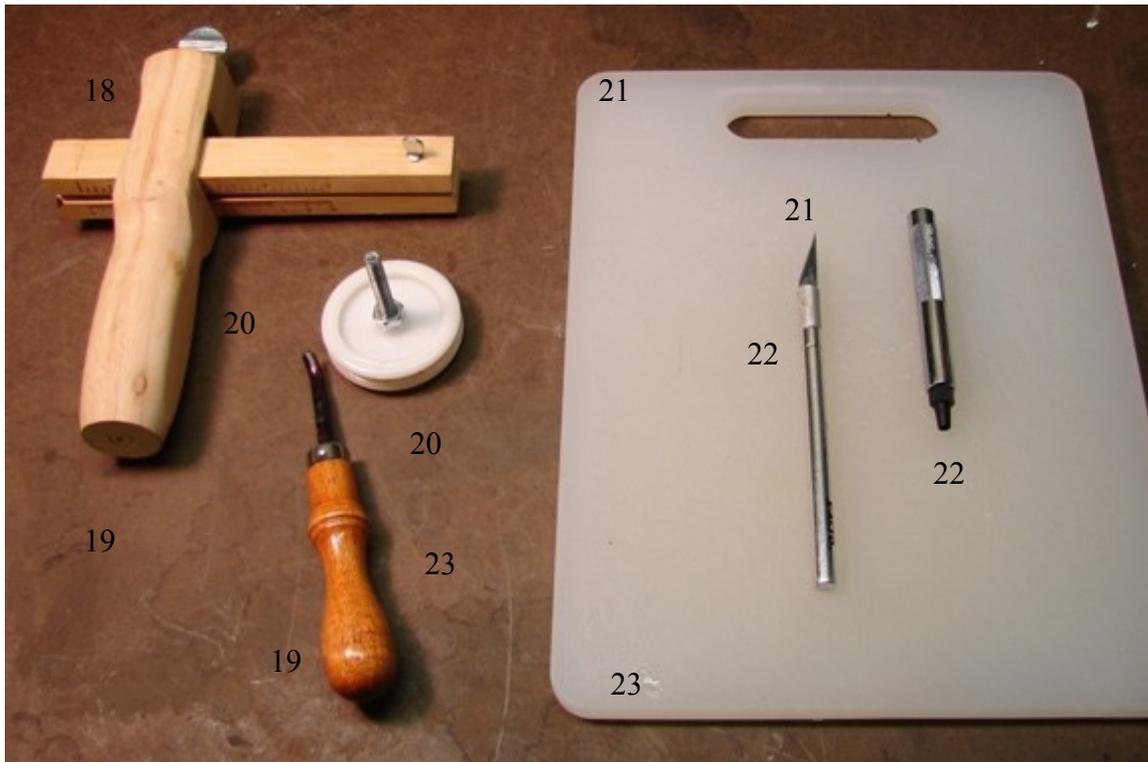
Many of the recommended tools are available at hardware stores, but most have to be purchased from catalogs or Internet merchants. The armor raising hammer (6) is available at Blacksmith's Depot (#219). This is an excellent hammer for working metal since it has a broad, but curved face that leaves minimal marks. Also consider a heavier cross-peen style and teardrop mallet for working with thicker sheets. These are also available from Blacksmith's Depot. It is best not to use a standard claw style hammer for working metal. If you are on a strict budget, a ball-peen would work better. The deburring tool (6) is available from McMaster Carr. Use this tool to smooth edges of cut sheet metal. The rivet sets (12, 13), while not essential, will make riveting easier and are available from the “in-stock” page at Clang Armory. Blacksmith's Depot has a new rivet block that performs the same function, but includes multiple rivet sizes. The step bit (3) can be used for deburring holes. These are very cheap from Harbor Freight.

While nothing is better than a good, high-quality anvil with a hardened & polished surface, the cast steel ones from Harbor Freight will get the job done. Coating the anvil face with leather keeps the rough surface from marring the work.

If you order the sheet metal in strips, then you will only have to cut them down to length and cut the proper shapes out for the shoulder pieces. The Harbor Freight throatless metal shear (14) works very well for this. Pneumatic hand shears will work as well, but scissor-style hand shears will not work. If you don't have easy access to a drill press, a metal punch will work.

## Leather working tools

These tools will simplify the preparation of the leather straps and are available from Tandy Leather.



Key to the tools in the above figure:

18 Strap cutter	21 X-Acto knife
19 Edge beveler (optional)	22 1/8 in. leather hole punch (if no drill press)
20 Nylon edge smoothing tool (opt.)	23 Plastic cutting board

## Materials necessary

Cold rolled sheet steel (16, 18 & 20 gauge) *	Sandpaper, 100 & 220 grit
2-3 sq. ft. of 5 oz. veg-tanned cowhide	Green Scotch-Brite pads
Scraps of 8 oz. veg-tanned cowhide	Steel wool
200 Copper, 1/8 in. flat head rivets	Metal polish (Nevr-Dull, Brasso)
100 Copper, 1/8 in. round head rivets	5-40 × 1/4 in. machine screws & nuts (optional)
16 Copper, 3/16 in. round head rivets	WD-40 or other metal oil
0.020 in. sheet brass for fittings *	Black spray paint (optional)
Poster paper for pattern	Neatsfoot oil

The leather is available from Tandy Leather, and the rivets, sheet metal & machine screws are available from McMaster Carr. It is recommended that the sheet metal be purchased in custom-cut strips rather than in large sheets. The exact amount needed should be determined after the paper pattern is constructed, and order extra for practice. 22 gauge sheet metal (steel or aluminum) can be used for patterns for some pieces as well. If the fittings are purchased, the sheet brass is not necessary.

## ***Suppliers***

McMaster Carr, <http://www.mcmaster.com>

Tandy Leather, <http://www.tandy-leather.com>

Harbor Freight Tools, <http://www.harborfreight.com>

Blacksmith's Depot, <http://www.blacksmithsdepot.com/>

Clang Armory, <http://clang.adkinssoftware.com/>

Online Metals, <http://www.onlinemetals.com/>

Fittings can be purchased from:

Keltica, <http://www.kelticaironagevillage.com/>

Matt Lukes, [panzerknacker \[at\] shaw.ca](mailto:panzerknacker[at]shaw.ca)

## **Assembly Overview**

Building a *lorica segmentata* may be one of the more challenging projects one can undertake in the re-construction of legionary kit, however none of the steps are extremely difficult or require expert skills. Care, patience and some practice beforehand are required, however. The first (and perhaps most important) step is to construct a paper pattern, sized to fit the wearer. It may also help to take some very thin sheets of metal and construct a prototype for the pieces that fit around the neck. This helps establish the proper curvature and ensures the pattern is the correct shape (since paper does not bend like metal).

The most tedious step is fabrication of the fittings. Since there are already fantastic tutorials on fittings, that will not be covered in this guide. Additionally, fittings can be purchased at reasonable prices from a couple different sources. Purchasing the fittings will very significantly reduce the amount of time required.

The next step is to prepare, cut and deburr the metal. This involves cutting sheet steel into strips, beveling the corners, filing the edges and polishing. Some edges will need to be rolled under and some may be flared up. This is the step that requires the most skill, and it is necessary to practice on scrap pieces of steel before attempting this step on the real pieces. After this, the rivet locations can be mapped out and the holes carefully drilled.

The next major step is to prepare the internal leather straps. This involves cutting the straps out of leather, determining the locations of the holes for the rivets, drilling the holes and coating with neatsfoot oil. The method used here for laying out the holes in the straps requires the strips to be straight, so the bending is done after that step. Most of the pieces can be bent by hand, but depending on the thickness of the metal chosen, some hammering on an anvil may be needed for the thicker pieces (again, practice this beforehand).

After all pieces are bent into the proper shape, the fittings and straps can be riveted on, a final polish applied, the four sections buckled together, and finally and great sense of pride will consume you as you put it on for the first time.

*Some final thoughts before you get started:* While this guide intends to be somewhat comprehensive, it is not a replacement for thought and planning on your part. So please don't rely on this or any other guide or patterns to the letter or expect them to solve all problems which may arise. And remember that there are many people willing to help when you get stuck. Also, be sure to read the safety instructions for your tools and take all necessary safety precautions, because no one is responsible for your safety but yourself.

# Patterns & Sizing

## *Constructing the patterns*

The best place to find a pattern for a *lorica segmentata* is the Legio XX website (<http://www.larp.com/legioxx/lorica.html>), where there are links to patterns for the Corbridge A & B cuirasses. These patterns may need to be scaled up before printing to ensure they are the proper size. The patterns will probably need adjustment, but these serve as a good starting point. A very important step is to make a pattern out of poster paper, making the necessary adjustments to fit the wearer well.

A *lorica segmentata* consists of several pieces:

- Left and Right Girdle Plates- The right strips are 1.5 inches longer than the left so there is  $\frac{3}{4}$  in. overlap where they meet in the front and in back.
- Lesser Shoulder Guards- There are different options on how to do these. The instructions in this guide use the default layout of having two smaller and two long ones on each side. The smaller ones have a trapezoidal shape, with the upper pair being rectangular.
- Upper shoulder Guards
- Breastplates
- Mid-collar Plates
- Top Back Plates
- Lower/Middle Back Plates (consider a slight deviation from the pattern such that the right ones are  $\frac{3}{4}$  in. longer to allow for overlap to match girdle plates)

## *Pattern adjustment*

There are a couple guidelines on how to adjust all the pieces. First, be wearing your tunic and subarmalis or at least something that will give the proper girth and shoulder padding. That  $\frac{1}{2}$  inch of padding in the shoulder makes a significant difference in the final fit. If you don't have a subarmalis, use a thick sock at a minimum to replicate the padding. Since this is such an important step, consider getting a friend to help and seek out advice from those who have done this before.

The width of the girdle plates should be very close to  $2\frac{1}{4}$  in. To get the length, measure the widest part of your torso. If you are in shape, it should be under your armpits and around your pectorals. Don't overestimate this. You can always loosen the top girdle plates a bit since there is some overlap.

However, if you make them too big, you can't tighten them and your left arm will get numb when carrying a scutum (trust me on this one). If you have a gut, things are a little more difficult. Since you will need to breathe, the best thing is to get the circumference at the widest part around the belly. Just know that the upper girdle plates will probably be oversized. Half of the circumference will be the length of each left girdle plate. Add 1.5" to this to get the length of the right girdle plates.

If you are shorter, you may need only 7 plates, but do not increase or decrease with width of the plates by much, rather, use more or fewer plates. The segmentata should come to just below the navel.

Next, the breastplates, mid-collar plates and backplates can be adjusted. The breastplates and mid-collar plates are mostly adjustable in length, and the backplates should be adjusted in any dimension necessary. To get the front-to-back length you may want to try making the top girdle plates and measure the distance from about  $\frac{1}{4}$  in. below the top edge of the front, over your shoulder, to about  $\frac{1}{4}$  in. below the top edge of the back. That will be what the combined length of the breastplates, mid-collar plates and all 3 back plates. The back section (three plates combined) is about the same as the length of the breastplate, the remainder being the mid-collar. Using simple algebra you can solve for the lengths. The widths of these plates can vary slightly as well. Keep in mind that the breastplates should overlap each other at an angle. This will tend to push the mid-collar plates apart, leaving room for the neck. Don't be tempted to make the curve in the breastplates much more than it is in the pattern.

The long end of the upper shoulder guards should be about the same as the breastplate and the center plate should be roughly the same length as the mid-collar plate. The lesser shoulder guards should not be adjusted. The dimensions are remarkably similar in the archaeological finds.

*But seriously, get some expert advice on this step.* There are many folks on Roman Army Talk who would be willing to help.

### ***Metal prototype***

It is useful to make a prototype for the neck pieces out of thin 22 gauge sheet steel or aluminum. This is thin enough that it can be bent by hand, and is able to capture the proper curvature of the plates better than paper. This is completely optional, but the benefit is when it comes time to bend the real breastplate and mid-collar plates, there is something to compare with, while hammering them out to the proper curvature. An example is pictured here.



## **Fittings**

Fittings can be purchased from Keltica ([www.kelticaironagevillage.com](http://www.kelticaironagevillage.com)). They sell an excellent set for the Corbridge A, all you will need to do is polish and enlarge the holes. Fittings may be available from other sources such as Matt Lukes, and rivet bosses can be purchased from Clang Armory. If you choose to make your own, please consult the guides on the Legio XX website (<http://www.larp.com/legioxx/lorica.html>) or Jared Fleury's website (<http://www.florentius.com/buckle.htm>) for buckles. If you go this route, it will at least double the amount of time it will take.

## **Cutting & Polishing of Metal Plates**

The first major part of construction is to cut the metal parts, give them a simple polishing and finish the edges and corners.

### ***Which thickness to use?***

It is common and acceptable to many groups to use 18 gauge (0.048 in) for all plates, but actual finds indicate that the thickness varied. Matt Lukes recommends on RAT to use 16 gauge sheet steel for the breastplates, mid-collar plates and top back plates & upper shoulder guards, 18 ga. sheet steel for the remaining shoulder pieces, and 20 gauge for the girdle plates. Using 16 gauge presents some additional challenges, because it is more difficult to work.

### ***Thoughts on pre-cut metal***

By far, the easiest way to cut the sheet metal for the girdle plates is to use a large industrial sheet metal shear. Very few people happen to have one in their backyard, so a good alternative is to just order the metal pre-cut into strips. Many suppliers will cut the sheet metal into strips for a nominal fee. At least having the girdle strips pre-cut since they are the most difficult to cut by hand, and optionally have

strips cut for other pieces that you can cut further into the shapes needed for the shoulder plates. Be sure to get extra strips as you are bound to mess something up your first time and will need to redo a piece.

### ***Cutting strips and plates***

Before any cuts are made, you should score all the cut lines with an awl and a straight-edge (or by tracing the pattern directly onto the metal with an awl). Hand shears can not handle 16-18 ga. steel, so a throatless metal shear is recommended for most cuts (esp. curved shapes). The actual Beverly™ shear costs well over \$500, but one is available for under \$150 from Harbor Freight. These are very easy to use, so long as you cut slowly and carefully. When tracing patterns that will have rolled or flared edges, don't forget to leave an extra ¼ inch. Another tip is to cut slightly outside the line and finish using a belt sander. Pneumatic hand-shears are a good option for long, straight cuts, but beware that you will lose a 3/16 in. strip for each cut, so adjust your layout accordingly.



*Tracing a pattern onto the sheet steel--note the score mark in the above pattern showing the allowance for the flared edge.*



*Cutting metal with a throatless shear*

### ***Finishing the metal***

After a plate is cut, snip off about 3/8 in. of the exposed corners and use a Dremel with a carbide grinding bit to round them off slightly to keep the edge from being too sharp. Rough edges can also be evened out with this same bit or by using a belt sander. Deburring is very important to keep from cutting yourself with sharp edges and can be done with a hand deburring tool or with a Dremel. A satin finish is most appropriate and can be achieved by scrubbing back and forth along a plate's length using green Scotch-Brite pads. The texture of sheet metal will have many tiny pores that give it this satin finish. If the metal is in superb condition, it may only need to be polished with steel wool to clean it. Over-sanding will polish out these pores and will yield more of a mirror-finish. Do not store your pieces outside, or you will notice rust will quickly ruin your polish.

### ***Painting***

You may wish to blacken the insides of the plates. This could be done by heating over a forge and polishing the top afterwards. Although it is not authentic, you could also spray paint the backs of the plates black to make it easier to prevent rust. If you do not paint the inside, don't forget to keep it oiled.

## Folding and Flaring Plate Edges

This step requires the most skill and should be practiced thoroughly on scrap beforehand. First, the bottom edge of the lowest girdle plate and a portion of the top edge of the top-most girdle plate must be folded under. The bottom girdle plates are also slightly flared as well. If you are using 18 ga for all shoulder pieces, you may either fold or flare the edges around the neck (but don't do both). Flaring is turning the edge up at 90 degrees and sanding the edge smooth. Although it requires fewer steps than folding the edge under, it requires more care to avoid scratches and marks on the flare. If you are using 16 ga. for the pieces around the neck, then flaring is a better option than folding the edge under.

### *Folding and flaring the girdle plate edges*

The easiest step here is to begin folding the edges for the bottom girdle plates. Start with the bottom-most girdle plates. Scribe a line all the way across on both the left and right plates  $\frac{1}{4}$  in. from the bottom. Line the jaws of a vice grip with thin cowhide and secure one end of the strip in the jaws, with only  $\frac{1}{4}$  in. sticking out (the scribe should be aligned with the top edge of the vice, see picture below). Begin by lightly hammering the top of the plate horizontally toward the direction that will be the inside of the plate. The armor raising hammer works best here, however a simple ball-peen may suffice. Work your way across the clamped section. Do not try to bend the metal too much at once, about a 15 degree bend is sufficient for the first pass, but do keep a smooth, flat surface and lightly tap any bumps to flatten them out. After the section clamped in the vice is bent, then unclamp, slide the piece over, and reclamp the next section. After the first pass all the way across the plate is complete, then start going the other direction, bending about another 45 degrees. Use a third pass all the way across again to bend the work to a full 90 degrees. After this, line an anvil with cowhide, and place the work on the leather. Strike the edge to bend the work the rest of the way over, again using multiple passes to keep any bends from being too severe (as this will cause warping that is difficult to smooth out). Finally, hammer the folded edge completely flat. Now, the edge needs to be flared out. This means securing in the vice grip again, only this time hammering the other direction to achieve about a 30 degree bend outward all the way across.

The top girdle plates have about an 8" section, under the armpits that are folded in the same manner, but not flared outward. The process follows as above (but with no flaring outward). These steps for the top girdle plates are pictured below.



*1. Starting the first pass. Bend only about 15 degrees. Notice leather padding on the vise jaws.*



*2. Starting the second pass. Bend over about another 45 degrees.*



3. The third pass is complete



4. Starting fourth pass on the anvil



5. The finished fold on the top girdle plate

### ***Folding edges for the pieces around the neck***

You can use the same technique for the neck pieces as the girdle plates, except only a small section can be hammered over at a time, and constant readjustment is required to accommodate the curved edge. It is also likely that the entire shoulder piece will not fit into the vise. In this case, start hammering as much of the edge as you can in the vise, and finish the rest on an anvil. It isn't too hard with 18 ga. or thinner steel. The alternative to this is to flare the edges outward.

### ***Flaring the edges of the pieces around the neck***

Although flaring actually requires fewer steps than folding an edge under, it is actually more difficult because extra care must be taken to ensure that the edge remains neat, and that no vice, anvil or hammer marks scar the flare. This wasn't a big deal when the piece was folded under, but now any mistakes can be easily seen. Essentially, just repeat the same steps as before, but hammer the edge in the other direction so it is bent outward. Again, do as much as you can with the vise, and when you get to the point to where the plate is too wide, lay it on top of a small anvil, with the flare pointing downward. Hammer the plate edge toward the side of the anvil, constantly readjusting the plate position as necessary. Be careful to ensure that you keep the anvil lined with leather and it also helps to

use a file to round off the anvil edge to smooth it out a little bit. If you are doing this step with 16 ga. steel, you will need to use a heavier hammer and will essentially need to pound the snot out of the edge to get it to bend over all the way. This will require much practice beforehand to master. After you are done, use a file and sandpaper to get the flared edge as smooth as possible, as this will be in contact with your skin quite often.



1. Starting the flare in the vice



2. Using an anvil for flaring



3. Finished breastplate flare

## Drilling

Drilling is a fairly easy operation, and if you follow a few tricks, you will be able to drill the holes quickly and accurately. There are two types of holes to be drilled into the pieces: holes for fittings and those for straps. It is very important at this step to begin labeling your pieces (especially the fittings), because it is likely that the hole locations will not be interchangeable.

### *Marking holes for leather straps*

You should measure and mark the locations for all the strap holes in a piece before you begin drilling. These can be drilled at this point for the girdle plates and most of the holes for the straps on the neck plates, but it will be best to wait for a few holes on the collar plates until you are laying out the leather straps (it can be difficult to predict where to drill beforehand). Measure and find the center point of each strip and mark it on the back side. Then, measure the location of each hole from the center point.

Once you have one plate, you can use it as a template for the others.

For the girdle plates, you need three sets of two holes, each 1.5 in. apart. The first set is in the center, and the other two are on each end. Measure each hole location from the center point and scratch a vertical mark with an awl. Measure about 1/8 in. from the upper edge and mark a horizontal line with the awl. Where the two marks intersect is the center of the hole; use a center punch to mark this position. It helps to hammer a punch even deeper to make drilling easier.

For the lesser shoulder guards, there are three holes, with the distance between them growing by about 3/4 in. for each piece toward the shoulders. Do not worry about marking the locations for the strap rivets in the upper shoulder guards, mid-collar plates or breastplates at this time.

### ***Drilling holes***

This is best done on a drill press to ensure a straight hole, centered exactly where you want. Use a 1/8 inch drill bit, and let as little of the bit protrude out as possible. Place the metal on top of a piece of scrap wood at least 3/4" thick. Lower the drill down and ensure that it will fall very close to the point that was punched earlier. If you punched it deep enough, the drill will "find" the location you punched and drill exactly where you intended. Hold the metal securely and turn the drill on and lower it just until it drills all the way through. After drilling all the holes, use a deburring tool (or a step drill bit) to deburr the hole and ensure a rivet fits through.

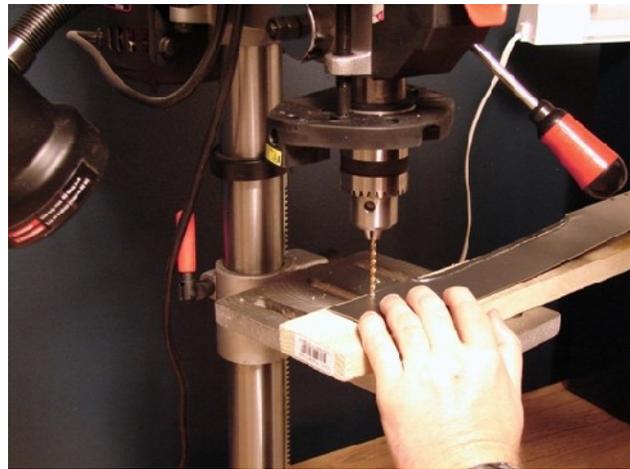
### ***Drilling holes for fittings***

It is not necessary to mark the fitting holes, rather just trace the location of the fitting on the front side of the metal plate with a pencil. Place the plate on the wood block just as before, but now place the fitting on top in the proper location, and drill through one hole. Place a flat head rivet through the hole from the bottom to secure the fitting's position and drill the next hole. Place another rivet through this hole and continue until all holes have been drilled. Use a new fitting for the next set of holes—they will not be interchangeable. You must label the fittings with the exact piece and location to ensure they don't get confused. A fitting will most certainly not fit through holes drilled for another fitting. Also, be sure you drill the hinge fittings on the breastplates, back plates and front/back upper shoulder guards so the hinge is 1/4 in. from the top edge to allow for the center plates to overlap these pieces. Also for the collar plates, be sure to account for the overlap in the flare if you choose that option. It is best to line these pieces up together to ensure they overlap properly before marking the fitting location. You will need to use a 3/16 inch bit for the 4 internal buckles on the back sides of the left and right top girdle plates and don't forget that there are no lacing loops on the bottom girdle plates (so don't mistakenly drill holes for those). This process is illustrated with the pictures on the next page. I hope you ordered extra strips just in case...

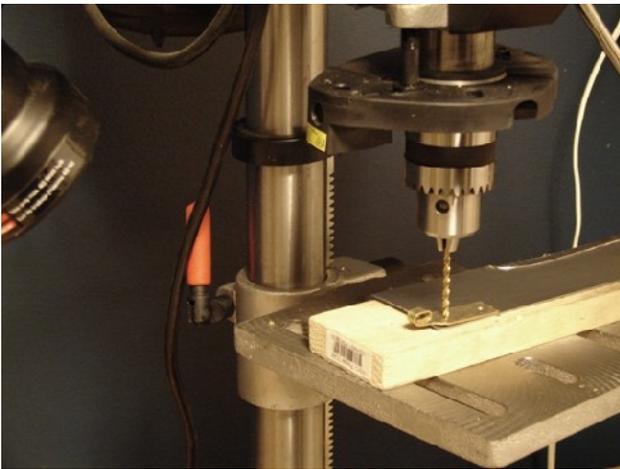
*One final note on drill presses:* spindle speed does matter. If your holes aren't coming out very neat, you may want to adjust your speed. Even cheap drill presses have adjustable speeds (by moving the drive belt to a different configuration). Consult your users manual for the proper speed and belt adjustments for the drill bit size and material type you are using. Small drill bits going into brass tend to use the highest speed and large drill bits in steel user lower speeds.



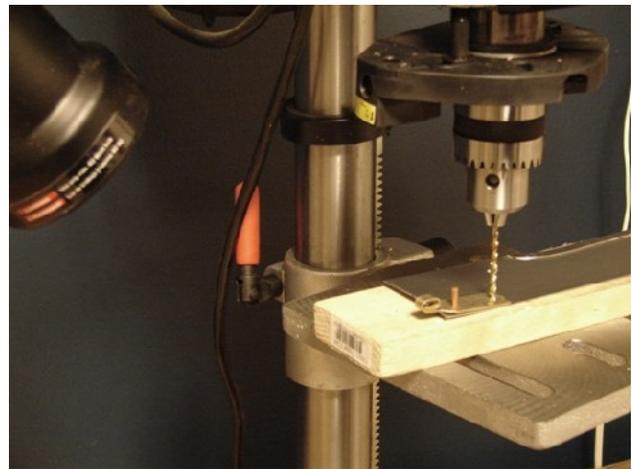
*Using a spring loaded center punch to mark the location to drill (scratch marks exaggerated)*



*Drilling a hole with a drill press*



*Drilling the first hole for a fitting*



*Drilling the second hole. Note the rivet in the first hole to secure the position.*

## **Leathering**

Cutting the leather straps is probably the easiest part of the process, and determining the locations of the holes isn't too difficult either. Several straps need to be cut: 6 for the girdle plates, 6 for the shoulder plate straps, 4 for the back plate straps and 4 for the exterior belts. 5 oz. leather is used for the internal straps, and 8 oz. should be used for the exterior belts. After the straps are cut and drilled, they should be coated with several coats of neatsfoot oil.

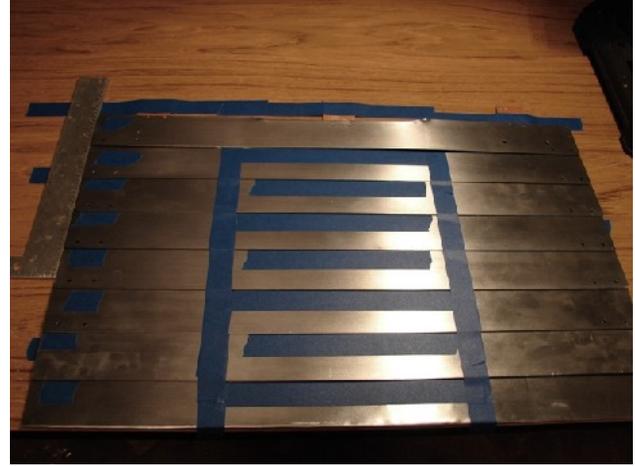
### ***Marking hole locations in girdle plate straps***

Cut 6 straps 1.5 in. wide and over 15 in. long out of 5 oz. leather using a strap cutter or X-Acto knife and straight edge. Clean a large work area on a table. Place the bottom girdle plate, top side up along the bottom edge of the table. Use the right-angle ruler and line each leather strap up exactly perpendicular to the plate, with about  $\frac{1}{4}$  inch of the straps underneath the girdle plate. Tape the plate and straps down very securely to the table so they can not shift. Line some tape  $\frac{1}{4}$  in. (or just slightly more) below the top edge of the girdle plate. Use a  $\frac{1}{8}$  in. drill bit and turn by hand through the holes in the metal to mark the position where the holes in the leather straps are to be drilled. Place the next plate so that the bottom lines up with the tape. Use the right angle measure to ensure it is parallel to the

bottom plate and aligned on the left side. Tape this piece securely to the table, and mark the positions of the holes for this plate. Repeat this process for each piece up to the top-most girdle plate. After you have marked the top holes, draw a line along the top of the plate onto the strap to indicate where to cut it so it does not stick above the plate. Repeat the entire process for the right girdle plates.



*Halfway through the layout of the left girdle plates. Use a drill bit and turn by hand through the holes in the top of each plate to mark the positions in the straps.*



*Completed the layout of the left girdle plates after all holes have been marked*

### ***Marking hole locations in shoulder plate straps***

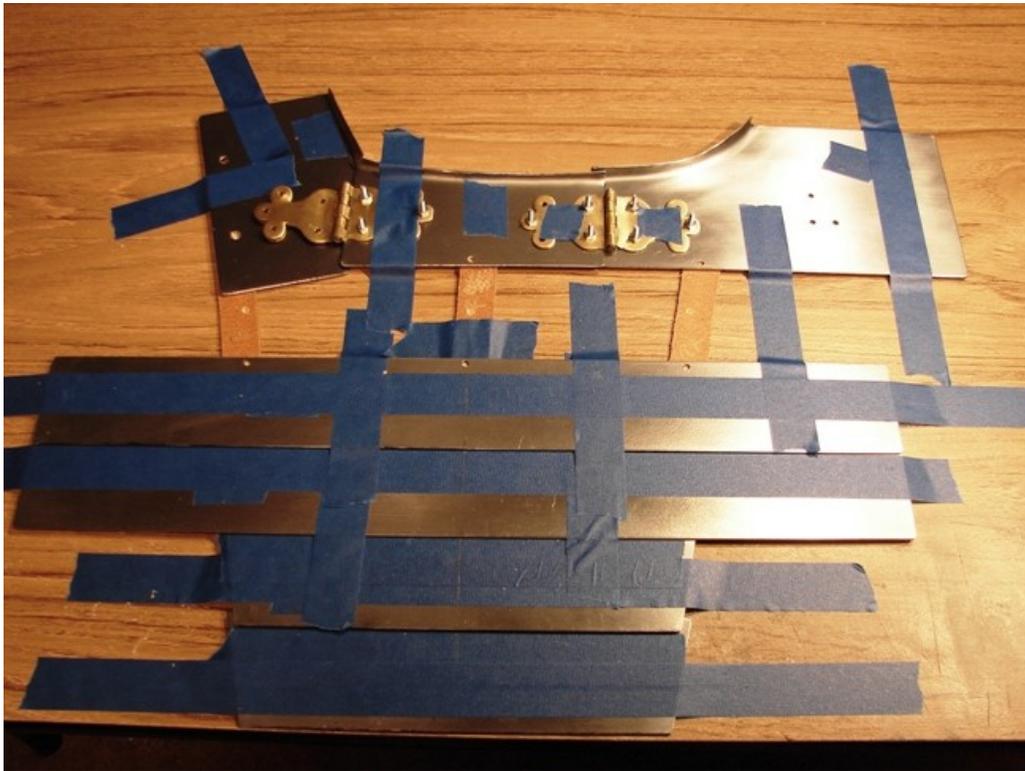
Cut 4 straps  $\frac{1}{2} \times 10$  inch long and two strips  $\frac{1}{2} \times 14$  in. out of 5 oz. leather. Follow the same process as the girdle plate straps. The straps on each end will be at an angle, however, and you may need to layout all the pieces to figure out the angle first before taping the straps down. After you layout the lesser guards, measure 2 inches and layout the neck pieces, using the machine screws to hold the breastplate, mid-collar plates and top back plates together with the hinges (pictured on the next page). You will now be able to determine the location of the strap holes in the breast plate, mid-collar plate and in the upper shoulder guards. Mark the proper rivet locations on these plates with a center punch and drill just as before. Placing the upper shoulder guards on last since they overlap the lesser guards and neck pieces. There is no strap hole in the top back plate, the strap will be fastened in hole used for the internal back plate straps. After the hole locations are marked, mark the end of the straps.

### ***Back plate straps***

The back plate straps will follow the same process, but leave them a bit longer and cut the bottom end to a triangular point. These are the belts that will fasten to the internal buckles on the top girdle plates. You will want to wait until everything is assembled before you determine the location for the holes in these straps for the buckles. This way you can ensure the proper amount of overlap.

### ***Drilling & cutting***

The best results are obtained by using a drill press to drill the holes instead of a punch. As with drilling the holes in metal, place the leather on a piece of wood and drill through. You may need to take an awl and stretch the hole and ensure an rivet can fit through. After drilling, use an X-Acto knife to cut the strips to the needed length. Coat everything with a couple coats of neatsfoot oil to soften it up. The shoulder straps need to be especially flexible for the lesser shoulder guards to hang correctly.



*Marking the shoulder plate strap holes, just before the upper shoulder guards are placed on top.*

### ***Preparing the external straps***

To cut the external straps, use four  $\frac{3}{4} \times 5$  inch strips of 8 oz. leather and cut one end of each to a triangular tip. Since 8 oz. leather is so thick, it helps to round the edges off. Use the edge beveler to bevel or shave off the corners. Use a 1/4-20 bolt through the nylon edge rounding tool and attach to a drill to spin it up. Moisten the edges of the straps and insert into the concave side of the rounding tool while it is spinning; do this on one side at a time. This will round off the sides of the straps for a neater appearance. Do not drill holes for the buckle just yet, that will come when you start assembling everything together. You can attach the fittings to the square end by inserting the leather between the the brass tabs and drilling through.

## **Bending**

### ***Girdle plates***

These are easiest to bend because it is possible to do this by hand. To get the proper shape, take some scrap strips, cut them to length, bolt one end together and fold around your torso directly underneath your armpits. Ensure that your arms go straight down and that the excess metal pushes out in the front and not onto the arms (this causes numbness when carrying a shield). This establishes the shape that all the pieces must conform to. Lay this out on a table and bend the other pieces around a large circular object to start the bend, then bend by hand trying to match each piece with the template. You do not need to try to account for overlap—that will take care of itself after you assemble everything. You can alternately try to bend these after the plates are riveted together.

### ***Neck pieces (breastplate, top back plate & mid-collar plate)***

If you chose to use 18 gauge steel and folded the edges under, bending these by hand won't be too hard. If you made the metal templates, simply bend these to the same shape. If you didn't, put on your tunic and subarmalis or at least try to mimic shoulder padding and bend these by hand until you reach the shape that fits most comfortably.

If you flared the edges and/or went with 16 gauge steel for these pieces, you will need to use a hammer and anvil. This is another step that requires significant practice beforehand. The idea here is that you will hold the metal at a slight angle to the anvil (back side up) and strike the metal just short of where it contacts the anvil. This will impart a slight convex bend. If you are using flared 16 ga. metal, you will need a fairly heavy hammer and will need to strike the flared edge quite hard (esp. on the mid-collar plate) to get the desired bend. This is where making that thin 22 ga. template really comes in handy, so you know the exact shape you need. You do not want to bend too much and try to undo that. Use a ¼ in. thick wood block to place underneath the metal to provide the support. It is also better to use a teardrop shaped hard plastic mallet for the surface as a heavy hammer is likely to leave marks on the surface and is only necessary on the flared edge. Lining your cheap anvil with leather will help avoid unsightly scars on the surface. I won't lie; that mid-collar plate is quite difficult to bend due to the deep curvature of that piece. Hammer marks are no big deal, so don't stress too hard to try to avoid them.



*Using a hammer to bend the flared edge on the breastplate. Notice the wood plank supporting the plate at an angle on the anvil.*

### ***Upper & lesser shoulder guards***

The upper shoulder guards are bent to a similar curvature as the corresponding neck pieces. With 18 gauge steel, you can bend by hand, but you may need to use the teardrop-shaped mallet for 16 gauge to make it easier. The lesser shoulder guards can also be bent by hand in the same manner as the girdle plates.

## **Riveting**

### ***Pre-assembly with machine screws***

The first stage of assembly should be to put all the girdle plates together using those 5-40 × ¼ inch machine screws. This will help you determine that the metal is sized and bent properly before riveting as well as verifying that the straps are drilled correctly. This is important, of course, since riveting can not easily be undone. You do not need to tighten the nuts very hard, but be sure to place the nut on the inside and screw head on the outside or it won't go together very well. Repeat this process for the shoulder plates and verify that all the bends and holes are as they should be and make any final adjustments. There's no going back after this point.

### ***Fitting installation***

The easiest part of assembly is to rivet the fittings on. Use the rounded head rivets for all fitting attachments. It also helps to use the rivet set for this operation. Insert the rivet through the fitting and through the hole in the sheet metal. Hopefully you kept the fittings well labeled so the fittings match the plates and the holes line up at the proper locations. Place the rivet head upside-down in the rivet set. It helps to place rivets through the other holes to keep the fitting in place. Nip the end off with the nippers, fairly close to the plate. Strike with a ball-peen hammer to upset the exposed end (the tail) until it makes a flat, very smooth surface. It is not necessary to strike very hard. Hold off on two of the internal buckles on the top girdle plates, because the leather straps will cover up the holes. After those straps are in place, just drill through them to install these fittings.



*The rivet on the left is about to be peened. The one on the right is simply there to keep the fitting from moving around.*

### ***Riveting the straps***

Start with the bottom-most girdle plates and work your way up. Use flat head rivets, with the head on the inside (against the leather strap). You will be peening the tail of the rivet directly onto the outside of the plate. This will be covered up once the plate above it is riveted on. Use round head rivets for the top girdle plates, inserted from the outside with brass washers on the inside. After those are done, start with the outermost lesser shoulder guard and work your way in toward the neck. Use the flat head rivets just as with the girdle plates. You can also rivet the straps on the back plates at this point (using the 3/16 in. round head rivets). Do the upper shoulder guards last, however, since they overlap all other pieces (use round head rivets for these as well). Riveting these pieces on can be awkward at this point, but creative use of duct tape and other mechanisms to hold the assembly in place will work to your advantage. Don't forget to use the rivet bosses on the upper shoulder guard rivets!

### **Final Assembly**

You should end up with four separate pieces. Before you can buckle these together you need to mark the location where the holes in the belts need to be drilled so the all the pieces overlap properly. You can drill on the drill press or use a leather punch; use a 1/8 inch diameter hole. Each of these can now be buckled together, but you are not done until you polish with some Nevr-Dull and spray with a coat of WD-40. The oil is absolutely necessary to prevent rust. Pictures of a completed *lorica segmentata* are below.



*Internal view*



*Front view*



*Rear view*

### ***Final thoughts***

Although there are many pictures of my personal segmentata here, keep in mind that it is not without its flaws. It is better to research the original finds and try to replicate those as much as possible before trying to copy someone else's. Also, don't stress about mistakes and hammer marks. These would have been present on the originals, so they can be present on yours as well. Finally, I understand that there will be other ways to do this. This guide only documents how I chose to do it.

## References

1. Bishop, M. C., *Lorica Segmentata*, available at <http://www.loricasegmentata.org>
2. Price, B., *Techniques of Medieval Armour Reproduction: 14<sup>th</sup> Century*, Paladin Press, 2000.
3. Fournier, R. and Fournier, S., *Sheet Metal Handbook*, HP Books, 1989.

## Appendix: Leather & Sheet Metal Measurements

Ga.	Cold-rolled steel thickness	oz.	Veg. tanned leather thickness
14 ga.	0.0747 in.	1 oz.	0.0156 in.
16 ga.	0.0598 in.	2 oz.	0.0313 in.
18 ga.	0.0478 in.	4 oz.	0.0625 in.
20 ga.	0.0359 in.	5 oz.	0.0781 in.
22 ga.	0.0299 in.	7 oz.	0.1094 in.
24 ga.	0.0239 in.	8 oz.	0.1250 in.

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### Legal Disclaimer

Don't try to hold me responsible for your negligence if you hurt yourself while trying to do this. Please consult the manuals that come with all of your tools and follow all safety instructions. My safety advice goes like this: keep all parts of your body out of contact with any blade, tool surface or sharp edge. Failure to do so may result in injury. Also, do not drop an anvil on any part of your or anybody else's body, since that may result in injury as well.

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