11.3.2 More to Pattern Welding

Points to be Addressed

There is a lot more to pattern welding than what I gave you in the preceding module. There is so much in fact that I'm not sure of where to start. Making a list always helps, so here goes:

1. How to make complex patterns *not possible with twisted striped rods*, e.g. the blade at the bottom of this picture?
2. Was anything else made by pattern welding? How about sax blades and lance heads, for example?
3. Were pattern welding techniques used outside of Northern Europe? When? What for and how?
4. How do pattern welded swords fit in with Celtic, Roman and Viking swords, and so on?
5. What about *quench hardening* of pattern welded blades? Was it done at all and if yes, was it really similar to the famous procedure used for Japanese swords?
6. How does pattern welding relate to Damascus? Are "damascened" blades better than others?
7. What about the revival of pattern welding in the 19th century?
8. How to treat the surface to reveal the pattern. Is "Japanese polishing" better than "normal" polishing followed by some etching?
9. The history of the *making* of pattern welded swords. Who made the first ones when and where? How did the technology develop and spread?
10. The history of the *discovery* of the pattern welded swords. How many have been dug out when and where. Where are they now? What kind of investigations took place? Why are the Danes so pissed about the Nydam treasure in Schleswig?
11. The *metallurgy* of the pattern welded sword. What do we know and what doe we guess?

That's a long list and it is probably not even complete. Some questions have short answers, some merit own chapters. And they all are interconnected. Some of these questions cannot be answered without referring to other ones.
Here I will deal quite shortly with these questions; details can be found in plenty of additional modules

To say it once more: If you want to know a lot about some of these topics, do what I said before:

Read Manfred Sachse's book!

You will find answers to *many* but not *all* of the questions above.
Now let's start.

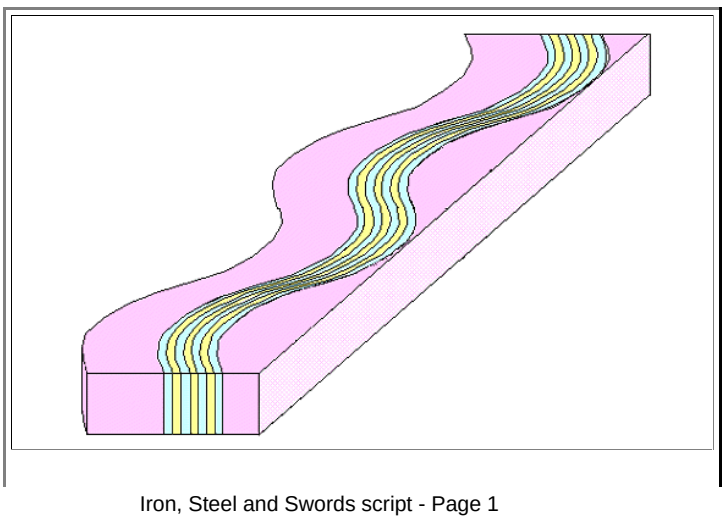
Complex Patterns: The Serpent in the Sword

Piling (partially) twisted striped rods can make a wealth of pleasing patterns; just look at all the examples given. There are, however, a few old pattern welded swords that did have rather unusual patterns that could be made with striped rods but *not* with *straight* rods. An extra process was needed for swords exhibiting a so-called "**serpent in the sword**" pattern, i.e. undulating lines running down the center of the blade. I have already shown an example; there are more in this link.
There is some speculation that these undulating lines symbolize something like serpents, symbols imbued with mystical powers. That's why the "Serpent" swords have their own module.
Maybe other patterns have some symbolic meaning, too? We don't know.

Special Module

Serpent swords

How does one make a serpent? If you have no better idea, this would work:



Making a serpent in the sword. One side has been ground to be flat.

- Produce a regular striped bar. Weld two other bars of whatever you like left and right. Forge into an undulating shape. Flatten the sides by grinding. You obtain one bar with a "serpent". Use it for making your sword.

This looks like tricky and time consuming work. I wonder if there is an easier way. All those modern smith who can make "serpents", for example Patrick Barta, would know. Ask them.

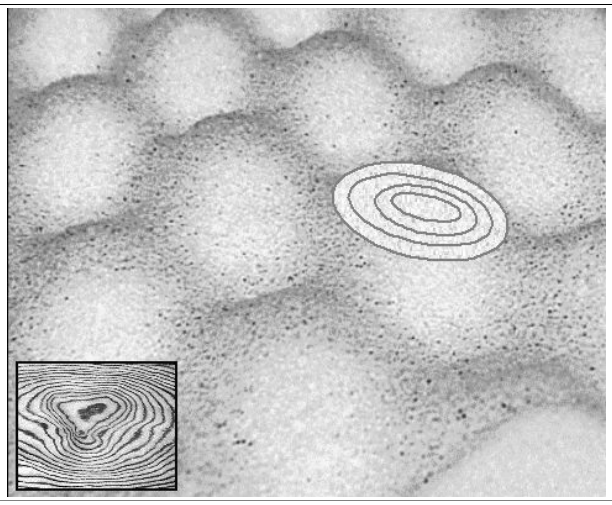
Complex Patterns: Wood Grain and Mosaic

There is more that one can do with striped rods. Here is the next example:

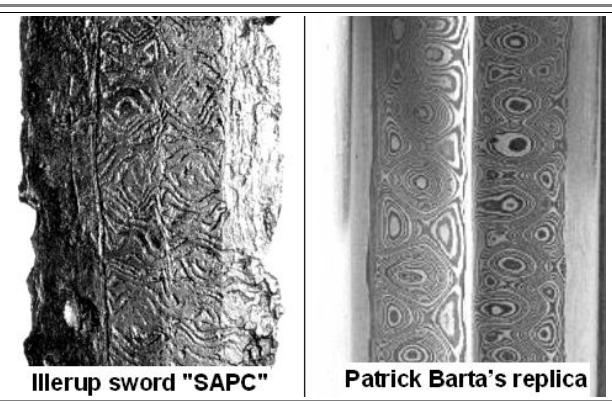
- Make the stripe rod a bit bumpy or wavy. Cut through it at more shallow angles. Look at wood and you know what you can get. The following picture gives an example:

Woodgrain

Now make your striped rod bumpy in a defined way. Make little hills or bumps (bang it from behind with a ball-shaped hammer, arranging the bumps in a kind of grid) until the surface looks kind of like an egg carton. Then grind it flat again. What you will get are more or less well-defined systems of rings on one side:



How to make mosaic patterns
A wood grain example in the lower left corner.



Mosaic patterns - old and new

Source: Left: Illerup Ådal; Vol. 11, 12
Right: From the Internet pages of Patrick Barta; http://www.templ.net; with friendly permission.

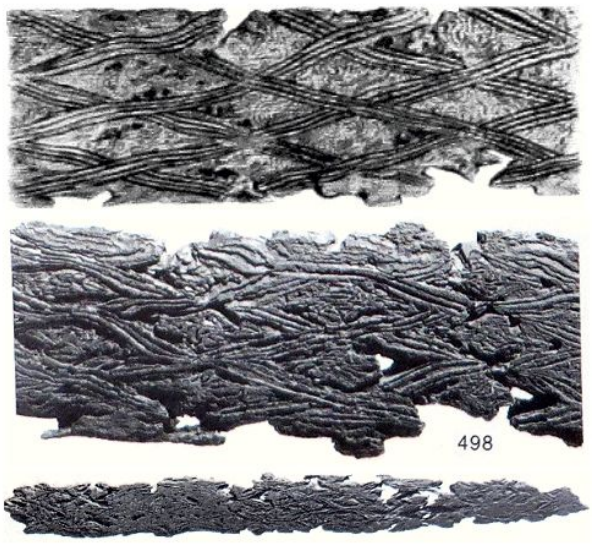
The "Illerup" sword shown is rather unique. It belongs to what I have termed "Illerup swords with special patterns" and there are several special modules that go with that:

Special Module **Bog Sacrifices**	Special Module **Illerup Adal**	Illustr. Module **Special Patterns**	Science Module **Sword Types**
The "Link Hub" for Danish bog finds, the places where many pattern welded swords were found	The place where many swords with special patterns have been found, often extremely well preserved	Details about some swords from Illerup with special patterns	The scientific classification of 12 sword types for the first 5 centuries AD.

Now let's look at pattern that cannot be made with striped rods.

Complex Patterns: Palmette and Chevron

Let's look at question **No. 1**: How to make **complex patterns**?
Some swords found in the Danish "bog treasures" and in other places showed what is often called a **chevron pattern**, a **palmette pattern**, and combinations of the two. There are many examples in the "Illerup Swords with Special Patterns" module. But we also find them in the probably very first publication that addresses pattern welded swords: Conrad Engelhadt's books about the Nydam finds.
Here is what I mean:



Chevron pattern
Top: Engelhard's picture of the sword part
Middle: Photograph of sword detail
Bottom: Photograph of what's left

Source: Engelhardt's book and 2)

Palmette pattern
Left: Engelhard's picture of the sword part
Right: Photograph of actual sword

Source: Engelhardt's book and 2)

The two swords are presently in the Copenhagen museum but apparently not on display. They are listed as No. 388 and 498 in 2) and carry the stock No. 25 234 and 25 249, respectively. They are probably from around 350 AD. The hilt of the "palmette" sword, however is in Schleswig:

Right: Photograph of actual hilt
Left: Engelhard's picture of the hilt

Source: Photographed in Schleswig; Engelhardt's book

There are more swords found in Danish bogs with chevron and palmette patterns; especially from Illerup Ådal. Not a lot but enough to ascertain hat these patterns were routinely made. This link shows details. Chevron and palmette patterns are quite interesting for a simple reason: How does one make patterns like these? And combinations thereof? Sometimes the chevrons are "filled" with palmettes; sometimes with something else - at last this is claimed in the literature. One example is shown here.

- How does one make pattern welded swords with chevron or palmette pattern? Good question. Looking at just the palmette pattern, one way would be to first making rods with a palmette cross-sectional pattern. Then cut your rod them into thin slices, which you weld on the blade, little piece by little piece.
  This leaves the question of how you make a rod with a palmette cross-sectional pattern? I simply don't know. I could guess but so can you; keep in mind that these guys also knew how to make wires that could be used for making finer structures. But even if you have a "palmette" rod, how do you cut it in thin slices? Precision metal saws did no yet exist.
  More to that in the Illustrations module. Here we simply note:

Illustration Module

Patterns

Nobody seems to know how chevron / palmette patterns were made!

Several authors deal with the problem by not mentioning it (e.g. the Illerup Ådal (Vol. 11, 12) books or J. Ypey's article 1)). I do have some ideas, though.

Now let's consider that I have answered - to the best of my ability - the first question: how to make complex patterns. It's time to look a the other questions

Quickies

What I'm going to do now is to run very briefly through some of the other questions from above. Here goes:

Question No. 2: Was anything else made by pattern welding? How about sax blades and lance heads, for example?

Answer: Yes.

- However, typically far less often, and mostly (but not always) less elaborate, as far as I can tell. If one looks at all the graves were some important person was buried with a sword and a sax, chances are that the sword was pattern welded and the sax was not.
  A few lance heads out of thousands were decorated with patterns, sometimes elaborate.

Question No. 3:: Were **pattern welding** techniques used outside of Northern Europe? When? What for and how?

Answer: Yes. Most of the time, mostly for show, and more or less as described above.

- Seriously now: Whoever worked with iron and steel at any time after, say, 1200 BC had to make a sword or anything else not too small by some kind of piling - except for the people using crucible steel. At the very least you had to "pile" your bloom. It is unavoidable that on occasion a random pattern results, and it is equally unavoidable that somebody somewhere sometime started to develop piling to a point where the pattern is no longer random but intended. In particular if Mr. somebody had seen a true pattern welded sword that somebody else had brought back as a souvenir from his business trip to Northern Europe. In contrast, some others like the Japanese might have gone for rather tricky structural and compositional piling but without the intention to produce a pattern.
  Be that as it may, it is now time to clear up a few statements about he iron / steel technology of "The Others" that come up all the time and rather confuses the issue.

  1. Nobody on this globe could make a sword that comes close in complexity to the pattern welded swords of the Celts / Romans after about 200 AD or even much earlier.
  2. Statements like: "For Japanese Samurai blades several thousands of layers were welded together, for oriental damascene *(meaning wootz)* we have a few hundred, and the Indonesian Palmor has a few dozen. In Europe, however, one rarely exceeds ten layers" [1)] (my translations) are pure BS. The statement not only confuses faggoting with piling, it also assumes that the quality improves with the number of "layers". We *know* that some North European sword smiths used faggoting because of Maeders's fine analysis, and we can assume with confidence that it was done most of the time as pointed out before. They had "thousands of layers" too, in other words.
  3. But what about the Chinese? Well - read this module. I do not doubt that "the Chinese" made fine swords around 200 AD, too, but I challenge you to prove that they made one that was more complex or simply better than some of the finest Nydam / Illerup swords.

  This is about iron and steel technology. So far I have not found a convincing reason that other areas on this globe were ahead of the Europeans as far as working with bloomery iron and steel was concerned.

Question No. 4: How do pattern welded swords fit in with Celtic, Roman and Viking swords, and so on?

Answer: It should be clear by now that the prime examples of pattern welded swords from the Danish bogs were from Roman "factories". That doesn't exclude the possibility that the were actually done by Celtic smiths who in 200 AD had become Romans.

- The term "Viking" refers to people living in Scandinavia (including parts of what is now Germany) from about 800 onwards. Their swords are a kind of in-between the old pattern welded after-Roman sword and the new "Ulfberht" all-steel type sword. I'll get to that.

Question No. 5: What about **quench hardening** of pattern welded blades? Was it done at all and if yes, was it really similar to the famous procedure used for Japanese swords?

Answer: Yes. And: maybe.

- This is a bit tricky. A smith might have quench hardened a blade by dunking it in water without having hardening in mind; maybe he just wanted to shorten the cooling down time. A smith might have conscientiously quenched his blade to induce some case hardening but failed because he didn't do it right (too shortly, for example) or because the steel he used for the edges was too low in carbon. Maybe he had phosphorus steel that can't be quench hardened, or worse, a steel with both phosphorous and carbon (plus God knows what else) where all kinds of things can happen during quenching.
  Only quench hardening produces martensite in "normal " carbon steel. Metallographic analysis of pattern welded swords did find martensite in some steel edges, so quench hardening was employed. And why not? We know that the earlier Celtic La Tène swords were not quench hardened while some early (not yet pattern welded but laboriously piled) Roman swords were. However, in other samples martensite is absent - indicating either no quenching or failed quenching.
  Was *differential quenching* used (that's the fancy name for what the Japanese did much later)? In other words, was only the cutting edge exposed to high cooling rates by protecting the bulk of the blade with some clay? There are

some indication for this this - but it is too early to tell.
I'll come back to the topic later

Question No. 6: How does pattern welding relate to Damascus? Are "damascened" blades better than others?

Answer: The answer to the first question is clear; I have dealt with that already: pattern welding has nothing whatsoever to do with Damascus.

The second question is a bit more tricky to answer. *Yes*, "damascened" blades are better than others because "damascened" or pattern welded blades had to be made with great cunning and care and thus were better than some banged together discount swords. *No*, because you can't beat a sword made from piling good homogeneous steels without producing patterns. *Maybe* because a composite of tightly interwoven rods of *relatively bad* steels could be better than a simple structure made from these steels. More to that later.

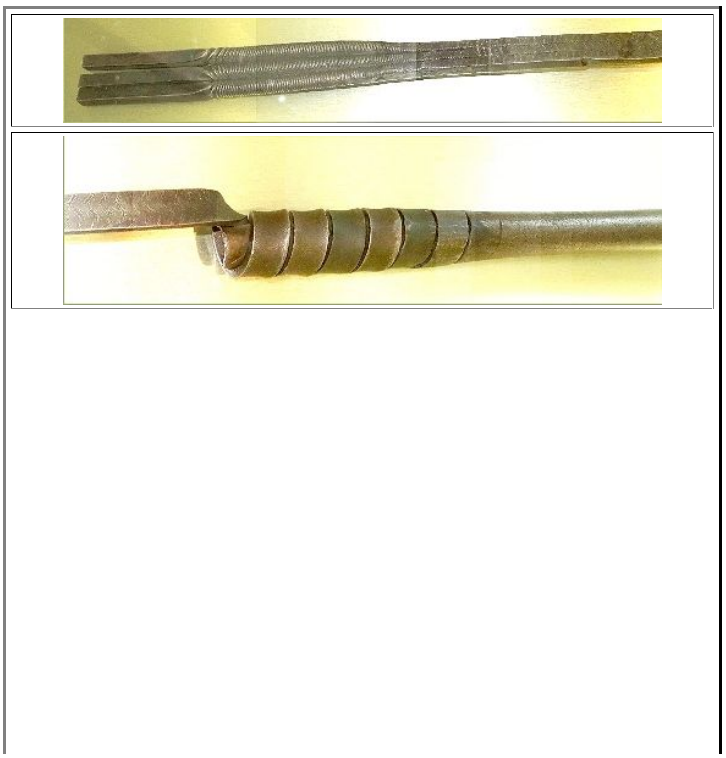
Question No. 7: What about the **revival of pattern welding** in the 19th century?

Answer: A very tricky question with no easy answer. I will perhaps write a special module as soon as I see "the light". Until then just a few points:

First let's look a the "facts" as far as I know them. Much of what follows is from Manfred Sachse's classic book.

- Pattern welding went never out of style in the "Orient". In contrast to Europe it was used for all kinds of things in Turkey and farther East, including armor, the Indonesian Kris, and in particular **gun barrels**.
- When guns an pistols became private items for hunting (or duelling) in the 17th century, the "West" became aware of the "Eastern" pattern welded gun barrels and started to import these items. That happened around the end of the 18th century, i.e. 1680 or so. It is certainly connected to the general awareness of "the Turks". First because one needed to throw them out of Europe (look up the 1683 "battle of Vienna", featuring the super-hero Prince Eugene of Savoy), and second because the Turkish culture and way of live made a big impression on the Europeans; witness, for example, the collection of "Turkish" things by August the Strong, Elector of Saxony and later King of Poland (1670 – 1733), now on exhibition in the "Türckische Cammer" (Turkish Chamber) in Dresden.
- However: military guns of all sizes in Europe were *always* made from one kind of (more or less) homogeneous steel or cast iron (if not from bronze or brass) and never by pattern welding. Private pattern-welded guns appeared around 1780; and some French, Belgian and English guys were instrumental in this.
- At the beginning of the 19th century several European places made "**Turkish damask**", foremost Liège in Belgium. It was a big industry and huge amounts of pattern welded gun barrels were made. An example of a catalogue is shown here; the real thing is right below.
- As far as swords are concerned, piling and pattern welding went out of style after - roughly - 900 AD and was completely abandoned around 1200 AD in favor of all-steel swords. These swords were typically piled with softer steel inside. They would not have shown a pattern. More or less in synchronously with pattern welded gun barrels, pattern welded blades became fashionable again and a "damascened" sword was common in the 19th century and the beginning of the 20th century in Europe.

The picture below illustrates what I'm talking about. It's a close up of a two-barreled gun with a torsion "damascene" pattern. It's done by the usual production of a twisted striped rod plus grinding. Then the patterned long strip is wrapped around a core, followed by fire welding. The final step is reaming the bore and straightning by experts. Complicated but not really of much interest to us because (in Europe) it is a 19th century technology.



Pattern welded gun barrel and how it's done

Source: Photographed in the weapon museum in Suhl, Germany

The problem I have with all of this can be put into two question:

1. How does the revival of pattern welded "damascene", somehow triggered by "Turkish damascene" tie in with the craze about wootz steel and blades around the same time? Note that any terms containing the word "damascene" in connection with patterned blades from the East could mean wootz blades or pattern welded blades, and possibly also blades with encrusted designs.
2. How did the general ubiquity of *contemporary* "damascene" swords and things in the 19th century influence the interpretation of the *ancient* pattern welded swords dug up systematically after about 1850? In other words: Did Conrad Engelhardt, when he dug up pattern welded Roman swords, recognize immediately that he looked at "torsion" damascene and so on? He did mention "damascened swords" but it is not clear what, exactly, he meant.

It is quite clear that there was some confusion - or better a lot of confusion - about patterns produced by using crucible steel ("wootz") and by pattern welding. We also know of bitter fights concerning the difference in quality of "damascened" blades vs. single steel blades, including increasingly cast steel. Nevertheless, how all of that connects is not clear to me. Do no forget that as late as 1819 the science titan Faraday made completely wrong pronouncements about the nature of (wootz) steel.
The second question is open. It will come up again when I deal with the history of discovering ancient pattern welding.

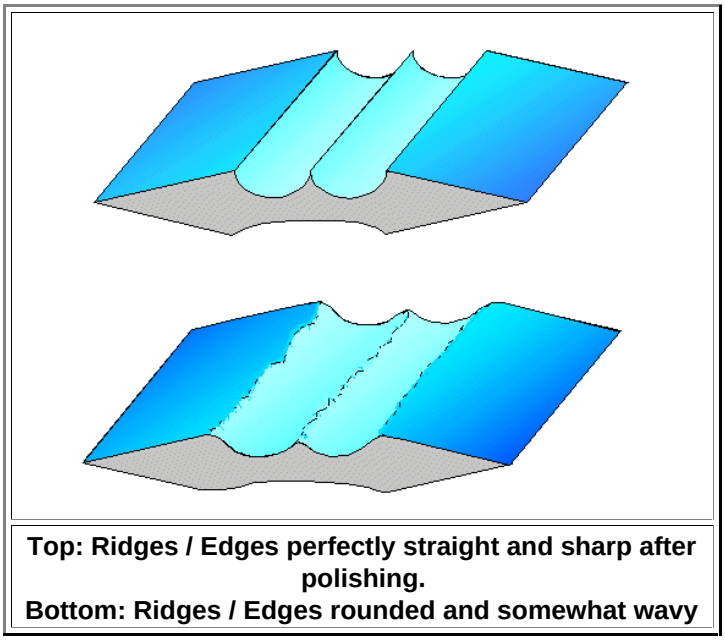
Question No. 8: How to **treat the surface** to reveal the pattern. Is "Japanese polishing" better than "normal" polishing followed by some etching?

Answer: Before I go into this, I advise you to look up this module.

OK, now that you are back, I can elaborate a bit about what that question implies. "Polishing", in the broadest possible meaning, entails one or several of the following points:

1. Generating the basic geometry of the blade surface by "polishing" (or grinding) off surplus material. A flat surface where this is wanted, a nice round fuller, or two, and so on. The surfaces should be reasonably "shiny".
2. The surfaces should be like mirrors, not showing any structure.
3. The surface should reflect the internal structure right after finishing polishing.
4. The surfaces should be good enough to allow some kind of chemical etching to produce a pattern. Either the macroscopic pattern intended by pattern welding or the microscopic pattern intended for structural investigation with microscopy.
5. The polishing should keep lines and ridges perfectly straight and ridges sharp.

The last point needs explaining; best done with a figure showing a sword with fullers in cross-section:



Top: Ridges / Edges perfectly straight and sharp after polishing.
Bottom: Ridges / Edges rounded and somewhat wavy

- The bottom one would look ugly and would be totally unacceptable, of course. However, the fighting value of the ugly sword would be just as good as the one with the perfect structure. In other words:

"Polishing" is mostly for show!

- So what about the Japanese method of polishing a sword blade that, according to Stefan Maeder, is so much better than what "we" did and do? In essence, Japanese polishing is a combination of point 3 and point 5 from the list above. It defines lines on the blade with the utmost precision and it reveals structures. The first part is not mysterious, it is just very advanced precision work.
  How does Japanese polishing reveal structures? And which structures exactly? Who knows; I have yet to see a scientific investigation of "Japanese" surfaces. The principle is clear, however. If the polishing particles in your slurry are harder then regular iron / steel, but softer than martensite, for example, the surface structure on the iron / steel part will be different from that on martensite, and that means you can "see" it.
  Find out more by reading the special module

Special Module

Polishing / Pattern

- Enough! The last three questions left (No. 9 - 11) will be dealt with in the next module.

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1) J. Ypey: "Damaszierung"; in: Reallexikon der Germanischen Altertumskunde", Band 5, S. 191.

2) Güde Bemmann and Jan Bemman: "Der Opferplatz von Nydam. Die Funde aus den älteren Grabungen. Nydam-I und Nydam-II. Band 2: Katalog und Tafeln". Pictures photographed thanks to the library of Gottorf castle.