11.4.2 Blades of Viking Era Swords

Several of the swords shown here and in the accompanying modules have standard pattern welded blades, technically no different from the ones the Alemanni made a few centuries ago. Some blades do not show pattern welding on first sight but might do so on second sight, especially if you look with X-ray vision. Some blades are all-steel blades, some carry large inscriptions on the blade (like VLFBEHRT) and some small inlays. In most cases we do not know the exact age of the blade. We might be able to date the hilt by its particular style or the owner of the grave by radiocarbon dating, but that doesn't necessarily give the age of the blade. Since good blades were passed on from father to son, possibly acquiring new hilts in the process, some Viking era blades might be far older than their hilt or the guy they were buried with.
As far as pattern welded blades are concerned, I have dealt with those. There seems to be no discernible difference in forging techniques between Alemanni pattern welded blades from around 600, say, and later Viking era blades from 800 or later. That is no surprise if all these blades were actually forged in the same region, along the lower Rhine. The people who made them may have been called Celts, Romans, Alemannis, Merovingians, Suebians, Franks or whatever - they had the necessary knowledge and passed on their skills and trade secrets to their progeny.
So let's forget about pattern welded Viking's swords and turn to the interesting stuff:

Viking era swords include all-steel swords

With **"all-steel" swords** I mean swords made mosly from relatively high carbon steel. Maybe from just one piece of steel but mostly by piling (or laminating) several pieces.
In fact, after about 800, pattern welded blades slowly disappeared and were replaced by all-steel swords. After about 1000 AD only all-steel swords were made. So far historians saw that as an indication that a kind of revolution in sword *forging* techniques took place. Here are some quotes:

- "Shortly before the tenth century, a *new technique of blade forging* was developed in the Rhineland. With this new innovation, Frankish smiths improved the strength of the blade while also enhancing its maneuverability. The new Frankish sword became highly sought after by the Northmen as well as by the Saracens to the south. This new technique created hard-elastic blades, which were entirely steel." 2)
- "Eighth-century blades were often damascened, but this practice began to die out in the ninth century, almost certainly as a consequence of *improved forging techniques* which produced blades of higher quality steel." 3)

Is that true? No, it isn't. We shall see why in a moment. First let's look at the alleged revolution from a customers point of view.
Pattern welded swords could only have disappeared because an alternative became available - all-steel swords - *and* because the customers went for it. What reasons could there be for this behavior of sword owners? I can think of four:

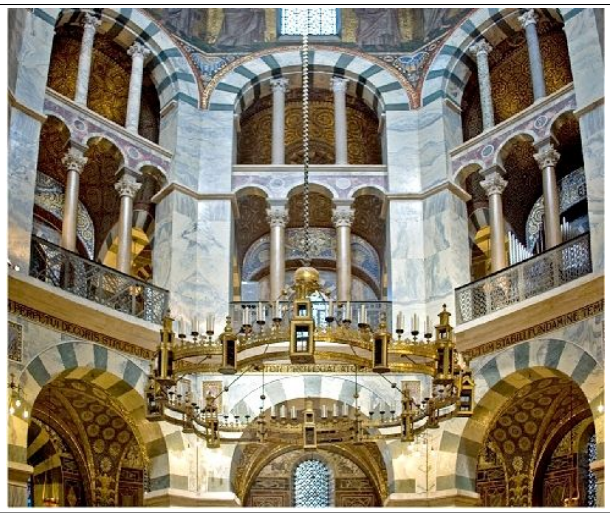
1. All-steel swords became just as good or even *somewhat better* than the pattern welded ones at *comparable* or even somewhat higher costs. Than important people will switch because it is cooler to have the new design. I'm talking fashion here, as I did before.
   If your status is low, you tend to emulate your superiors and thus you also go for an all-steel sword with the new cool shape but with a cheap hilt / pommel.
2. All-steel swords became *much better* at *comparable prices* than pattern welded swords. Than anybody in the army or otherwise given to killing people by the sword needed to have one; your life is at stake here, after all.
3. All-steel swords became *much cheaper* at *comparable quality*. Than all the upper crust guys who were required by their liege lords to equip largish numbers of soldiers with weapons would be going for it.
4. All-steel swords were *much better and much cheaper* than pattern welded ones. No comment needed; large amounts of money could now be made.

The *first* point is easy to see. It is simply inconceivable that people who could afford a costly pattern welded sword with a fancy hilt would settle for less than the best. They might have wanted something different than their ancestors for fashion reasons but they would not settle for something technically inferior. As long as pattern welded swords carried the day, all that could be done fashionwise was to change the hilt and to a smaller extent the shape of the blade. As long as your sword is in its sheath nobody sees your fancy pattern welded blade anyway, so it makes sense to announce your high status by fancy hilts and pommels. So full steel swords must have been at least as good or likely better than pattern welded ones - and that is perfectly reasonable from a "theoretical" point of view; I'll get to that.
The *second* point is obvious; no need to enlarge upon it here.
The *third* point need a bit of explaining. During the building of the Frankish empire and ever since, the organization of warfare changed. Before Charlemagne and his peers, an "army" was more or less an assemblage of whatever local chieftains could raise and put at the disposition for their Overlord. Their equipment consisted of whatever they could

afford; swords were rather rare; look a the statistics here. Charlemagne's army, while still put together from men send by his vassals (in particular bishops and abbeys), was heavily armed with *standard equipment* that was specified in detail. This cost money and one can be rather sure that cheaper products that met specifications were favored by the ones who had to pay. The soldier himself had nothing to say in that.
The *fourth* point is obvious once more.

- Whatever point carried the day sometime and somewhere after 800 AD, one thing is also sure: It takes a while before the last conservative will catch on. I bet that some of you still use old-fashioned incandescent light bulbs, read texts printed on dead wood, and drive non-German cars. So we must expect that some pattern welded swords were still around after 800 AD, carried by dyed-wool conservatives or people in more remote places (like England) who hadn't heard yet of the newest fashion on the continent. We must expect fairly long transition periods for the whole of Europe even so transitions might have happened far more quickly locally.

Before I go on, let's recall an important fact: While we perceive the building of the Frankish empire as a succession of war and constant fighting between the top dogs, quite the opposite is true. Many *normal* people in the heart of Europe finally did have some peace and quiet for an appreciable stretch of time. The chaos days after the fall of the Roman empire were about over, civilization and business recovered. Huge stone buildings were raised once more in the cities, like the **Palatine chapel** of the Aachen cathedral; built by Charlemagne between 796 and 805:



Inside the Palatine chapel in Aachen, Germany

Source: Internet a large

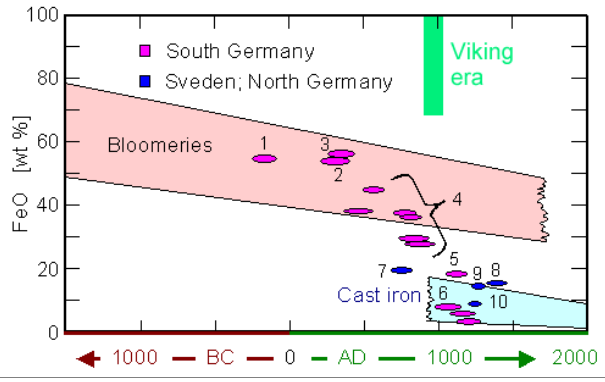
- You need peace and some prosperity to build something like that, not to mention a lot of iron and steel tools. While we focus on swords, let's not forget that the amount of iron and steel used for making swords and other armor was always just a small percentage of *all* the iron and steel coming out of smelters. Only a small percentage of all the people then living had a sword - but everyone had a knife, and most a scythe, a sickle, a hatchet or the stuff listed here. In conclusion, the manufacture of iron and steel products must have increased enormously in the 8th / 9th century to meet the demands of prospering societies and the ever-growing armies. This requires not just a hell of a lot more people doing business as usual, this requires changes at doing things. In the limited space where iron ore was dug out, more people would just have been in each others way, for example. And even if digging could be scaled up in *one* place, you could not scale up the charcoal supply very much without exhausting the local supply rather quickly. Increasing the iron production required to open up new mines, increasing the productivity by getting more iron out of the same amount of ore, and utilization of low grade ore that didn't do so well in old fashioned bloomeries. And so on.
  How was that done? I don't know but I do know that you, the ancient iron monger, did not sit down, mulling all this over, and then proclaim the new ways of doing things. You just did it. And you go better at it. A rapidly increasing demand for iron and steel in relatively quiet times when one didn't have to run for one's life all the time, facilitated plenty of improvements for all steps in the production chain just by doing business. Investors were around, and you also were more receptive to what you heared from other regions, including from empires far away.

So exactly what happened to the iron and steel technology between 750 and 1100, more or less the "Viking era"? And why?
Let me tell you right away: It's not just me who doesn't know - nobody knows! That doesn't mean that there are not plenty of theories around. Thankfully, we do not need to look much into anything older than 20 years or so, since more recent findings overthrow most of that. There is still a lot of confusion, however, and on top of that we have the enigma of the Ulfberht swords; more to that in the next subchapter.
One thing, however, is obvious to me and should now also be obvious to you:

Forging techniques did not improve. It was iron and steel smelting technology that improved.

Obvious, isn't it? No? Well - just remember: Forging techniques already peaked 400 or so years ago. A technique that produced elaborate pattern welded swords like the ones found in the Danish bogs has already reached its climax, you simply can't improve upon it. You can only get better products if you supply the master smith with better materials on a reliable base. And no, it's not that the old master smiths had not discovered hardening by quenching and so on. You can take for granted that at least some old smiths had working recipes for proper hardening that would have worked all the time with good material. If they failed, it was the materials that failed them. Of course I'm no the only one who noted that. Alan Williams, to name just on major sword researchers, knows it, or Mikko Moilanen

To illustrate my claim that the demise of the pattern welded sword was not due to better forging but better smelting techniques, I give you a remarkable figure:



FeO ("Wüstite") content in slags vs. time

Numbers 1 - 6 refer to Hermaringen, Großkuchen, Essingen-Weiherwiesen, Frickenhausen, Beuren-Weileräcker, and Metzingen - all towns on the "Schwäbische Alb" not far from Stuttgart / Germany and right in the heartland of Alemanni and Frankish sword production.
No. 7 denotes slag from Kippenheim / Südbaden / Germany; No. 8 Kierspe / Middle Germany; No. 9 Vinarhyttan and No. 10 Lapphytta; both in Sveden

Source: Andreas Hauptmann und Ünsal Yalcin paper

The shaded areas show typical *FeO concentrations in slag* from bloomeries or blast furnaces. Concentrations decrease a bit with time because smelting temperatures went up a bit with time. The (elliptical) dots show measured concentrations.

This is an amazing figure. It is based on research conducted by two heroes of archaeometallurgy who we have met many times before: **Ünsal Yalcin** and **Andreas Hauptmann** from Bochum, Germany.
What does the figure show? Back when I discussed iron smelting in some detail, I made abundantly clear that the slag of "classical" *bloomeries* always contains a lot (50 % or more) of iron monoxide (FeO) or wüstite for reasons that are quite clear. In contrast, *blast furnaces* produce cast iron only if operated with limestone as flux and concomitantly low wüstite concentration in the slag.
Analyzing the wüstite concentration in slag from different times thus allows to see when the transition from bloomeries to blast furnaces occurred. This is exactly what the figure shows.

Three conclusion are unavoidable:

1. The transition was gradual and took about 500 years. That is not surprising. We know that blast furnaces and bloomeries coexisted for many 100 years and that some furnaces produced a bloom and cast iron at the same time,
2. The transition started long before 1000 AD. Around 800 AD, the time of interest here, it had definitely occurred in the "Schwäbische Alb" region" from where much of the data originated.
3. Smelting with limestone as flux (the reason for the low FeO concentration) was done in several places at the latest in the 11th / 12 th century - considerably earlier as assumed so far.

This goes right against the "old" wisdom positing that a more or less sudden jump in (forging) technology happened around 900 AD. What really happened was that a continous progress in smelting technology occurred when things calmed down again somewhat before the dawn of the "Viking era" as pointed out above. That iron smelters could make cast iron far earlier as believed until not so long ago is not the crucial point, however. The crucial point is that smelting became far more more efficient (you got more iron /steel output for the same input of ore / flux / charcoal) *and* that the quality of the bloom increased. In short: you got more *and* better iron and steel. The bloom was less spongy, cleaner, and various steel grades could be recognized and separated more easily. Control of phosphorous and sulfur was possible "somehow" too, and so on and so forth.

- Don't forget that the iron / steel people of old *knew* about the different grades of "iron" already for centuries by then. They somehow could tell phosphorous iron from plain iron, enabling them to make striped rods, and they knew about the existence of carbon-rich "hard" steel that they used for the edges. They might have believed that iron and steel were two completely different materials that just looked about the same (like silver and tin, for example) but that doesn't matter. They had working recipes to deal with the stuff, including the far-from-trivial fire welding and all kinds of quenching procedures. If a master smith failed in making a good product on occasion, it was the material that must be blamed, for sure. There was simply no way to distinguish between good raw material and not so good one as long as the basic criteria were met.
  I won't give you details about the better melting processes and the resulting increase in product quality because we don't have a clear picture yet. The articles of Yalcin and Hauptmann give some hints but much more work is needed (including a better understanding of the smelting process itself) before the last word will be in. The key, however, was to raise the temperature by better smelter design (including making it bigger) and by paying attention to details: kind of ore, pre-treatment of the ore, adding suitable flux (instead of unknowingly relying on the gangue and smelter walls), and so on. That should sound familiar
  All things considered, in the 9th century and later sword smiths by and by could obtain better grades of iron / steel at lower prices. That resulted eventually in better *and* cheaper swords because forging became easier. What more do you want?

So let's look at blades now. Below is another figure that will tell us a lot. It shows the quality of about 100 swords from the 10th to the 17th century; thus going far beyond the Viking era. The quality is expressed in seven "grades" like in German schools. A "1" is the best grade, a "7" the worst (see the details in the lower part of the figure). All these swords have been investigated in some detail by metallography.
About 10 swords per century is of course a ridiculously small number for drawing general conclusions. But that is all we have and against the odds some insights will emerge. Here is the figure; the colors symbolize the numbers of swords investigated.

Time	10th *)	11th	12th	13th	14th	15th	16th	17th	Σ
Grade									
1	14								
2									7
3									7
4	34								1
5									28
6									5
7	11								
Sums	59	48							

*) The 10th century swords are exclusively swords with inscriptions of the "Ulfberht" type

The grade definition for 11th – 17th century is: Swords made out of		Color Coding of Numbers
1	a single piece; hypereutectoid/eutectoid steel	0
2	one single piece of hardened steel	1
3	several pieces of hardened steel	2 - 3
4	several pieces of steel, not hardened	4 - 5
5	iron core and hardened steel edges	6 - 7
6	undetermined core; unhardened steel edges	8 - 9
7	wrought iron	> 10

Improvement of sword quality after the 10th century

Source. Alam Williams book: "The Sword and the Crucible".

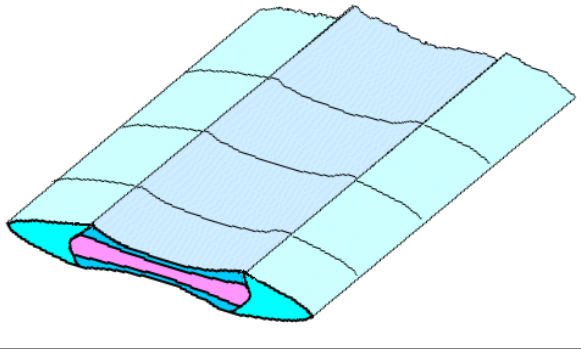
Neglecting for a moment the 10th century "Viking" blades we recognize that the general quality went up as time progressed. Very slowly, indeed, but swords did get better. Of course, at any time and in any place there were excellent smiths and iron masters *and* poor ones, like in every profession. We must thus expect a certain spread in quality at all times. Nevertheless, general improvements must be due to improvements in the material quality and not so much in forging techniques.

- The figure also shows in full brutality the **enigma** of the 10th± century **"Ulfberht" swords**. Among the 59 "Ulfberth's" swords investigated by (mostly) Alan Williams, about 25% were *better*, and about 20 % were *worse* than anything produced in the next 500 years! The rest merits something between grade 2 and grade 6. I have lumped them together because the grade definition used for these swords is somewhat different from the one given for the other swords. There are about 170 known ""Ulfberht" swords, so Alan Williams investigation covers about 1/3 of them and thus has some statistical significance.
  We have a real puzzle here. A possible and highly advertised solution was given by Alan William; the next sub-chapter will go into that.

For now we will look a bit more closely at the blade construction after pattern welding went out of style.

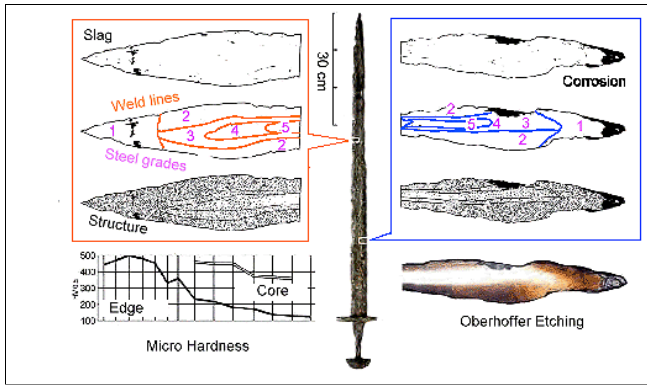
Making All Steel Blades

While the best possible sword consists of one kind of homogeneous steel with possibly quench hardened edges, I also allow swords in this category that were made from several pieces of steel by piling. That seems to bring us right back to the old Celtic times before pattern welding came into its own. However, we need to add one more criterium: Piling now is done for almost sure with *faggotted* steel and any piece runs (typically) the *whole length of the blade*. Something like this:



Schematics of an all steel sword

Sorry for the clumsy graphics so let's look at the real thing:



All steel sword from the 9th century
1-3 denotes steel, 4 and 5 wrought iron
Large picture

Source (5)

This is one of 16 swords (Grave No. 438) that have been found in an early medieval stronghold at the site of Mikulèice (Hodonín county) in Moravia (Czech Republic); it dates to about 830 - 900. Moravia bordered the Frankish empire and the swords found there are likely "Frankish". More to this sword and its brethren can be found in this advanced module.

The sword shown is remarkable for several reasons:

- It is an early *very good* all steel sword with at least partially high-carbon steel
- It carries an inscription done by encrusting twisted striped rods. It is no longer readable but it is definitely *not* "VLFBERHT".
- It has been expertly quench-hardened.
- It was forged by piling long strips of (probably) faggoted iron / steel as shown in the schematic figure.

In essence, it is built like a late pattern welded sword but with a coating of good steel instead of the thin "veneer" of ground-down twisted striped rods. That makes sword forging a hell of lot easier, of course. That is also true for other all-steel swords. They were made by piling strips of steel lengthwise to a (possibly) iron core. The steel edges might have been welded on, too. Quench hardening was used. As usual, very good and very lousy swords were made this way. Some were used for show and equipped with fancy hilts and scabbards, some were inscribed with symbols or names. Fancy hilts and inscriptions were not necessarily a sign of high quality, however. Some of those swords had actually rather bad blades.

Now you wonder. I have been going on at full steam in this subchapter for quite a while and all that happened in the transition from pattern welded swords to all-steel swords is use plain steel as a kind of veneer on the blade instead of fancy patterned one? Well, yes, but it is not as simple as it looks.
The question to ask is why that didn't that happen much earlier? The sword might not look as good but it is much cheaper. At least the not-so-rich ones who lived by the sword should have provided for a good market. I can think of several reasons:

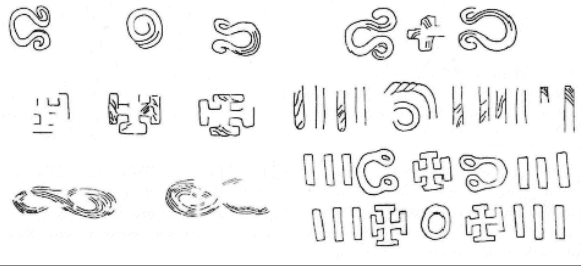
- The rich upper crust did not want the hoi polloi to own swords at all and saw to it that swords were not affordable for all but a few. That only changed in the 9th century when their liegelord asked then to provide standardized equipment for the soldiers they were obliged to provide.
- A pattern welded veneer actually made for a better sword than a solid steel sheet. This could be the case as long as the solid steel is still pretty bad, with lots of microcracks, large slag inclusion, phosphorous-rich zones, and so on. It then was prone to cracking in contrast to an entangled mix of bad steel. A fitting analogy is rope made from twisting many not-so-good thin filaments. It is always better than a rope with the same diameter consisting of only one not-so-good filament.
- The surface of all-steel swords doesn't look so good if the steel is not uniform and contains visible flaws (large slag or oxide inclusions, large cementite particles, patches of different luster due to inhomogeneous phosphorous distribution, ...). A patterned surface nicely covers all that. A certain amount of dirt is far more obvious on a white carpet than on one with a a salt-and-pepper pattern.

There might be more to this but the general direction is clear: All-steel swords need more and better steel that pattern welded ones. We're right back to square one: Progress in smelting technology enables all-steel swords. No progress in forging technology is needed. Making all steel swords is actually easier than making pattern welded ones.

Inscriptions

Many of the early all-steel swords carry long inscriptions while pattern welded swords from the same time horizon typically don't. Why is that?
A simple explanation suggests itself: An inscription would not go well with the pattern. True enough - but only for huge inscriptions made in a comparatively artless way. If you consider what artisans could do with the hilts, one could have expected very fine and beautiful work on (small) parts of the blade, too.

Some pattern welded swords actually do carry "inscriptions" or adornments. Earlier ones may sport small figures made from copper or other metals. Later ones might have symbols like rings inlaid into the blade by making the symbol from a thin twisted striped rod that is hammered into the blade. The smith may first make suitable grooves into the blade that hold the symbol or he might just bang the (cold) symbol directly into the (hot) blade. Mikko Moilanen has written a detailed paper about his experiments concerning that; read it if you want to know more.
I'm not yet talking "+VLFBERH+T" or "INGELRII" signatures but far more simpler stuff, essentially just **symbols** of some kind, as shown here:



Symbols and strings of symbols found on "Viking era" swords

Source. From Janet Lang's and Barry Ager's work

All-steel blades might also carry these kinds of insignia. The better known ones carry the words mentioned above; here is an example Two questions come to mind:

1. What do these symbols, strings of symbols or whole words signify?
2. Why is the material rather special (twisted striped rods) but the execution rather artless?

It appears that nobody before me has asked the second question. Why did the famous smith Ulfberht (if he existed) mark his swords by inlaying crude letters of iron and not perfectly made letters of gold or copper? The prize couldn't have mattered, just look at the hilts! Moreover, why were the rather crude and uneven letters not made from some suitable wire of, e.g., phosphorous steel, providing for a nice contrast to the blade steel, but made from hard-to-make twisted striped rods?
We have two question here. I do not know the answers but I can guess:

The letters are rather big, crude and uneven because:

1. your opponent should be able to see them. And you didn't want to give him aesthetic pleasure upon beholding your drawn sword, you wanted him to become afraid.
2. It was important that the smith made the inscription. Some specialized goldsmith could do some fancy engraving on any blade but *only* the smith who had forged the blade could make the kind of inscription we are looking at here. I had to be done *during* the forging of the blade. You can't do it properly anymore after the blade has been finished; it would oxidize to much and get too thin if you heat it up an bang it, and grind it again. The inscription had to be done by banging to into the blade at high temperatures and thus cannot be delicate and precise.

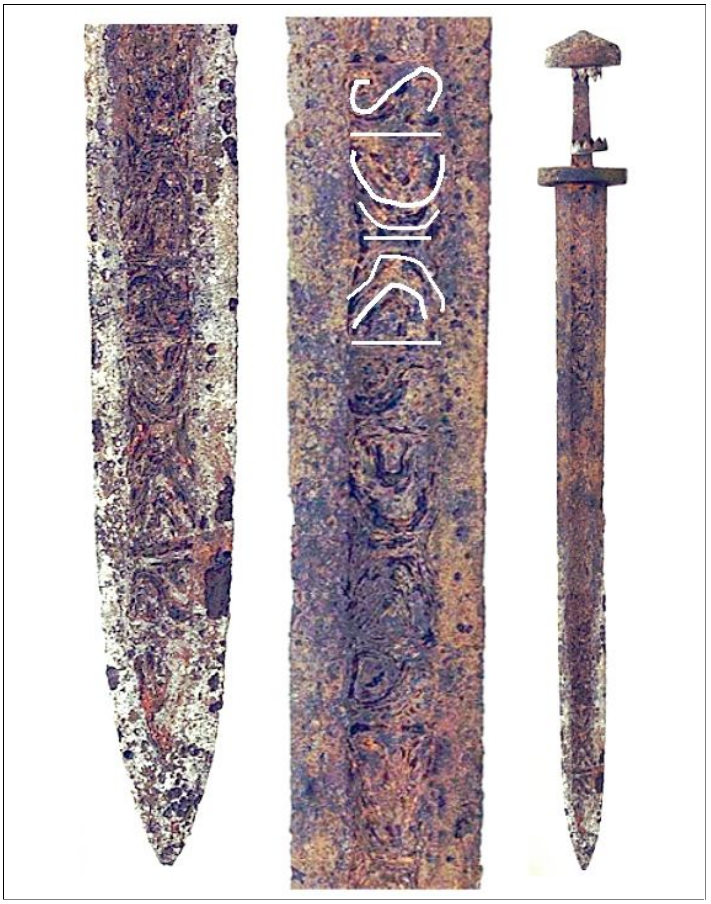
Why were the letters made from a twisted striped rod wire? My answers are:

1. I don't know. A simple phosphorous steel wire would have done just as well. In fact, simple steel wires were also used; as far as one can tell mostly in later times.
2. I can speculate. Let's look at an analogy. The portraits of all your noble ancestors that are hanging in your hall had been painted by "classical" artists, who needed many sittings before they were done. Now, when it is your turn, all famous artists paint like Picasso, are done after a few hours, and the result takes some getting used to. You would feel much better if the guy who did you at least signs his work by painting a perfect little miniature picture in the corner in the classical way. That tells you that the guy actually could have done it in the old-fashioned way. If he doesn't work in the old-fashioned way any more, he must be convinced that the new way is better.
   King Harald V of Norway might have felt this way upon beholding his portrait displayed in the Town Hall of Oslo:

King Harald V of Norway

Source: Photographed in Oslo Town Hall

Now we are almost ready to give the "+VLFBERH+T" swords and his brethren a close look. Before I do that, however, I need to look at a new and unexpected find: The fully embellished or encrusted 8th century sword shown below was found in a Bavarian lake by a diver. "It was examinated by the archaeological department of the university and by the archaeological state collection of Bavaria. The metallurgic and x-ray examinations proofed the sword to be authentic" reports the finder in the vikingsword.com forum.
Here it is:



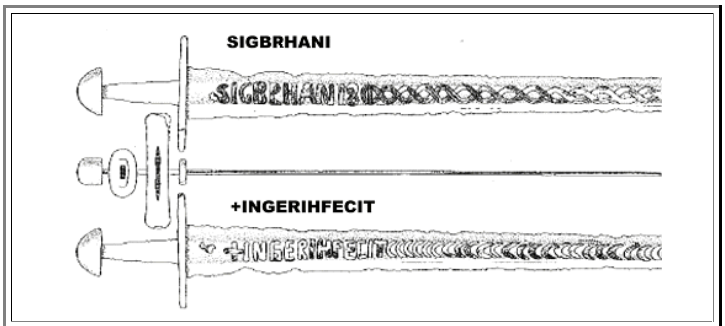
Symbols and strings of symbols found on "Viking era" swords

Source: vikingsword.com forum

To me this sword looks like an all-steel sword that has been embellished with a recurrent motive (as crudely outlined) on both sides in essentially the same twisted striped rod technique that was used (later?) for making the VLFBERHT etc. inscriptions. This might be totally wrong but if it isn't, we might make some wild guesses:

1. Making incrustations into all-steel blades with twisted striped rods was a well-known technique in South Germany, then part of the Frankish empire. Far more complex designs (like the one above) then what we know from the VLFBERHT swords were made.
2. The known "VLFBERHT" swords are probably just a tiny fraction of all comparable swords produced in the Frankish empire. Maybe they were mainly for export?
3. Maybe swords with complex embellishments made from twisted striped rods that include letters and symbols were just a variant or advancement of the old technique of having a kind of veneer with the usual twisted striped rod patterns? A kind of missing link between old-fashioned pattern welded swords and the all-steel "Viking" or better "Frankish" kind of sword? We just don't know because we have almost no surviving examples?

Well - there seem to be some more remarkable survivors. One is resting in the Provinciaal Museum van Drenthe, Holland. Here it is:



The Drenthe sword, front and backside

Another late and strange one

Source: **Jeff Pringle**; in a 2011 "myarmoury.com posting. The primary source is an article by J. Ypey [7)]

- Unfortunately we do not have a date for that sword. If it is "early", say around 800, it would go right with what I surmised above. It is probably form later times, however; Ypeysuspects the 10 th century
  While I'm not sure what the "SIGBRHANI" on one side fo the blade signifies; the "+INGERIHFECIT" cleary means that some Ingeri... has made ("fecit") that sword.

  Note that the letters are clearer and neater than in many VLFBERHT swords, and that the "**+**" sign only appears with the signature of the maker, supporting Anne Stalsberg's hypothesis that this signifies the orgin from an "industrial" enterprise run by a monastery.
  But I'm getting ahead of myself. Only time (and looking a the "hidden treasures" in museums) will tell.

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2) Valerie Dawn Hampton: "Viking Age Arms and Armor Originating in the Frankish Kingdom", The Hilltop Review (2011) Vol. 4, Iss. 2, Article 8.

3) Simon Coupland: "Carolingian Arms and Armor in the Ninth Century" Viator: Medieval and Renaissance Studies, Vol. 21 (1990) (???); on-line via "De Re Militari", Soc. for Medieval Miltary History.

4) Ünsal Yalcin: "Zur Technologie der frühen Eisenverhüttung", Arbeits- und Forschungsberichte zur SÄCHSISCHEN BODENDENKMALPFLEGE, Band 42 (2000), p. 307 - 382
Andreas Hauptmann und Ünsal Yalcin: " Archäometallurgie der früh- und hochmittelalterlichen Eisenverhüttung im Vorland der Schwäbischen Alb". In: "Abbau und Verhüttung von Eisenerzen im Vorland der mittleren Schwäbischen Alb", Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg, Band 86 (2003) p. 127 - 158.

5) Jirí Hošek, Jirí Košta, **Patrick Bárta**: "THE METALLOGRAPHIC EXAMINATION OF SWORD NO. 438 AS PART OF A SYSTEMATIC SURVEY OF SWORDS FROM THE EARLY MEDIEVAL STRONGHOLD OF MIKULÈICE, CZECH REPUBLIC", Gladius, XXXII (2012) pp. 87 - 102
Patrick Bárta is well-known to us as the master smith who makes all these beautiful replicas of pattern welded swords.

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