A Guide to the Metallurgy of Edge Tools in The Davistown Museum

The following synopsis of steelmaking strategies from 1900 BC to 1930 AD has been compiled for the ongoing show *Art of the Edge Tool* at The Davistown Museum. This synopsis relates specifically to steel producing strategies used by edge toolmakers to make the tools of the shipwright. By definition, edge tool also includes knife and sword making and may also be defined as including the art of making razors, scissors, scythes, and other sharp cutting tools. The focus of The Davistown Museum exhibition is on the art of edge toolmaking for the shipwright, rather than, for example, the art of the Japanese pattern welded sword maker. **The following synopsis is therefore, in essence, a guide to the metallurgy of the edge tools in The Davistown Museum collection.**

The following synopsis has two sections: **Steelmaking strategies 1900 BC – 1930 AD and Edge toolmaking techniques from 1900 BC – 1930 AD**. The tool collection of The Davistown Museum also includes large numbers of drop-forged low carbon and alloy steel tools, wrought iron, malleable iron, and cast iron artifacts, as well as artifacts with no iron or steel content whatsoever (e.g. our late 17th century or early 18th century flax breaker).

For a broader survey of all the steel and tool making strategies and techniques, see our special publication 42: *A Glossary of Ferrous Metallurgy Terms: A Voyage through the Labyrinth of Steel and Tool Making Strategies and Techniques 2000 BC to 1950*.

A Guide to the Metallurgy of the Edge Tools at the Davistown Museum: Art of the Edge Tool

An Exhibition Opening in June 2007

The following steel and tool making strategies and techniques were used for the forging of the edge tools included in The Davistown Museum's Exhibition *Art of the Edge Tool*.

I. Steelmaking Strategies 1900 BC – 1930 AD

1. **Natural Steel: 1900 BC – 1930 AD**

   Natural steel was made in direct process bloomeries as occasional nodules of steel (+/- 0.5% carbon content (cc)) entrained in wrought iron loups, by altering the fuel to ore ratio in the smelting process, producing heterogeneous blooms of malleable iron (0.08 to 0.2% cc) and/or natural steel (0.2 to 0.5 cc and higher) or by carburizing bar or sheet iron submerged in a charcoal fire. Manganese laced rock ores (e.g. from Styria in Austria or from the Weald in Sussex, England) facilitated natural steel production; as a slag constituent, manganese lowered the melting temperature of slag, facilitating the more uniform uptake of carbon in the smelted iron. The first documented production of natural steel occurred at the height of the Bronze Age, 1900 BC, by the Chalybeans, using the self-fluxing iron sands from the south shores of the Black Sea. Occasional production of bloomery derived natural steel edge tools continued in isolated rural areas of Europe and North America into the early 20th century.

2. **German Steel: 1350 - 1900**

   German steel was produced by decarburizing blast furnace derived cast iron in a finery furnace, and after 1835, in a puddling furnace. German steel tools are often molded, forged, or cast entirely of steel as exemplified by trade and felling axes without an inserted (welded) steel bit. Such tools were a precursor of modern cast steel axes and rolled cast steel timber framing tools; German steel shared the world market for steel with English blister and crucible steel until the mid-19th century.

3. **Blister Steel: 1650 - 1900**

   Blister steel was produced by carburizing wrought iron bar stock in a sandstone cementation furnace that protected the ore from contact with burning fuel. It was often refined by piling, hammering, and reforging, into higher quality shear or double shear steel or broken up and remelted in crucibles to make cast steel. Blister steel was often used for "steeling" (welding on a steel cutting edge or bit) on axes and other edge tools.

4. **Shear Steel: 1700 - 1900**

   Shear steel was made from refined, reforged blister steel and was used for "steeling" high quality edge tools such as broad axes, adzes, and chisels, especially by American edge toolmakers who did not have access to, or did not want to purchase, expensive imported English cast steel. The use of shear steel was an alternative to imported English cast steel for making edge tools in America from the late 18th century to the mid-19th century.

5. **Crucible Cast Steel: 1750 - 1930**

   Crucible cast steel is made from broken up pieced of blister steel bar stock, which is inserted into clay crucibles along with small quantities of carboniferous materials (e.g. charcoal powder). After melting at high temperatures, crucible cast steel was produced in 5 to 25 kg. batches and was considered the best steel available for edge tool, knife, razor, and watch spring production. Due to lack of heat resistant clay crucibles, extensive production of high quality crucible cast steel didn't begin in the United States until after the Civil War.

6. **Brescian Steel: 1350 - 1900?**

   Brescian Steel was a common Renaissance era strategy for making steel in southern Europe, for example, for the condottiers of the Italian city states. Wrought or malleable iron bar stock was submerged and thus carburized in a bath of molten pig iron. Brescian steel cannot be visually differentiated from German steel or puddled steel, both of which were produced from decarburizing pig iron.

7. **Bulk Processed Steel: 1870 f.**

   After the American Civil War, a number of new strategies were invented for producing large quantities of steel, especially low carbon steel, required by the rapid growth of the industrial age and its factory system of mass production. The first important innovation was Henry Bessemer's single step hot air blast process, followed by several variations of the Siemens-Martin open hearth furnace and electric arc furnaces. For edge tool production, the electric arc furnace supplanted, then replaced, crucible cast steel in the early decades of the 20th century. A few modern drop-forged edge tools are included in this exhibition as examples of modern bulk process steel producing strategies.

For more information on these later techniques, including the drop-forging of the all cast steel ax, see:
Davistown Museum special publication 42: A Glossary of Ferrous Metallurgy Terms: A Voyage through the Labyrinth of Steel and Tool Making Strategies and Techniques 2000 BC to 1950

This publication is available for hands-on perusal by museum visitors.

Also see the exhibition handout: **Edge Toolmaking Techniques**

Art of the Edge Tool

II. Edge Toolmaking Techniques 1900 BC – 1930 AD

Shaped and forged by Hand

A. Forge-welded: edge carburization by heating followed by hammering and additional heat treatment

B. Steeled: the welding on of a steel bit to an iron shaft or body

C. Pattern welded: the welding together of alternating layers of sheet iron and steel, used by knife and sword makers; seldom used by edge toolmakers

D. Molded: the shaping of short lengths of hot malleable iron or German steel bar stock in an iron pattern; sometimes the iron pattern was water cooled. Not used after blister steel became widely available (1700)

Shaped and forged by Machine

E. Rolled: cast steel hot rolled into bar stock, then socketed and ground or forged

F. Casting: cast steel hot rolled into bar stock and then shaped by drop-forging entirely by machines

G. Drop-forging: the hydraulic pressing of low carbon steel and malleable iron into tool forms by using dies as patterns

Most hand tools made in the 20th century show no evidence of hand work, but in a minority of cases (e.g. the ax) there is no clear distinction between the hand-forged and the machine made tool until the late 20th century. Most edge tools made before 1930 are “hand-forged” or “forge-welded” to some extent, no matter the technique used to “steel” their edges. The trip hammer and the water wheel are examples of machines that assisted edge toolmakers in the forging of their tools. The advent of the modern rolling mill (Henry Cort, 1784) for hot rolling cast steel bar stock did not end the long tradition of hand-forging an edge tool. When the Collins Axe Factory began drop-forging all steel axes sometime after 1837, many smaller ax companies continued hand-forging and hand hammering axes they produced, often with the aid of other machinery, well into the 20th century. The evolution from hand-forging to machine forging (drop-forging) hand tools was thus a gradual process. One goal of the creative economy of the post-industrial era is the revival of handmade hand toolmaking strategies and techniques.