

Appendix E

Excerpts from Moxon

The following is an excerpt from Joseph Moxon's 1703 *Mechanick exercises or the doctrine of handiworks* (Moxon [1703] 1989, 56-62).

Moxon's excerpt is an excellent summary of an educated layperson's take on steel- and iron-making strategies and sources. Moxon makes notable references to forging wrought iron, case hardening, and the excellence of steel made in the Forest of Dean, later the location of R. F. Mushet's ironworks, that enabler of Bessemer's pneumatic bulk steel process. He also notes Danzig as a source of Swedish steel, cementation furnaces having been built there in the second half of the 17th century. He comments on the Spanish steel of Biscayne, used for French trading axes, German steel and the role of the Rhine River in its transport to German toolmaking centers, and the high quality of Venetian steel. He also notes both the excellence and difficulty of creating Damascus steel. Moxon continues with a survey of contemporary interpretations of annealing, hardening, and tempering steel and ends with a famous aphorism of the time: "form thick and ground thin."

to stop the Socket from sliding too far upon the *Shank*. From this Shoulder, the rest of the *Shank* must run Tapering down, to the small end the *Bullet-bore* is fastned to. You must Work with it, as you were taught to Work with the *Square-bore*.

Of *Twisting of the Iron*.

Square and flat Bars, sometimes are by Smiths, *Twisted* for Ornament. It is very easily done; for after the Bar is Square or flat Forg'd (and if the curiosity of your Work require it truly Fil'd) you must take a *Flame-beat*, or if your Work be small, but *Blood-red beat*, and you may twist it about, as much or as little as you please, either with the *Tongs*, *Vice* or *Hand-vice*, &c.

Of *Case-hardning*.

Case-hardning is sometimes us'd by *File-cutters*, when they make course *Files* for Cheapness, and generally most *Rasps* have formerly been made of Iron and *Case-hardned*, because it makes the outside of them hard. It is us'd also by *Gun-smiths*, for Hardning their Barrels; and it is us'd for *Tobacco-boxes*, *Cod-piece-buttons*, *Heads* for *Walking-slaves*, &c. And in these Cases, Workmen to set a greater value on them in the Buyers esteem, call them *Steel-barrels*, *Steel-tobacco-boxes*, *Steel-buttons*, *Steel-heads*, &c. But Iron thus hardned takes a better Polish and keeps the Polish much longer and better, than if the Iron were not *Case-hardned*. The manner of *Case-hardning* is thus, Take *Cow-born* or *Hoof*, dry it thoroughly in an Oven, and then beat it to Powder, put about the same quantity of Bay-Salt to it, and mingle them together with stale Chamberly, or else White-wine-vinegar. Lay some of this mixture upon the Loam, made as you were taught

taught *Numb. I. fol. 13.* And cover your Iron all over with it; then wrap the Loam about all, and lay it upon the Hearth of the Forge to dry and harden: When it is dry and hard, put it into the Fire and blow up the Coals to it, till the whole Lump have just a *Blood-red-beat*, but no higher, lest the quality of your mixture burn away and leave the Iron as soft as at first. Then take it out and quench it: Or, instead of Loam, you may wrap it up in Plate Iron, so as the mixture may touch every part of your Work, and blow the Coals to it, as aforesaid.

Of several sorts of Steel in common use among Smiths.

THE difficulty of getting good Steel makes many Workmen (when by good hap they light on it) commend that Country-Steel for best, from whence that Steel came. Thus I have found some cry up *Flemish-steel*, others *Swedish, English, Spanish, Venice, &c.* But according to my Observation and common Consent of the most ingenious Workmen, each Country produces almost indifferently good and bad; yet each Country doth not equally produce such Steel, as is fit for every particular purpose, as I shall shew you by and by. But the several sorts of Steel, that are in general use here in *England*, are the *English*, the *Flemish*, the *Swedish*, the *Spanish* and the *Venice-steel*.

The *English-steel* is made in several places in *England*, as in *Yorkshire, Gloucestershire, Sussex, the Wild of Kent, &c.* But the best is made about the *Forrest of Dean*, it breaks Fiery, with somewhat a coarse Grain. But if it be well wrought and proves sound, it makes good Edge-tools, Files and Punches. It will work well at the Forge, and take a good Heat.

The *Flemish-steel* is made in *Germany*, in the Country of *Stiermark* and in the *Land of Luyck*: From thence brought to *Colen*, and is brought down the River *Rhine* to *Dort*, and other parts of *Holland* and *Flanders*, some in *Bars* and some in *Gads*, and is therefore by us call'd *Flemish-steel*, and sometimes *Gad-steel*. It is a tough sort of Steel, and the only Steel us'd for Watch-springs. It is also good for Punches; File-cutters also use it to make their Chissels of, with which they cnt their Files. It breaks with a fine Grain, works well at the Forge, and will take a welding Heat.

I cannot learn that any Steel comes from *Sweden*, but from *Dantzick* comes some which is call'd *Swedish-steel*: It is much of the same Quality and Fineness with *Flemish-steel*.

The *Spanish-steel* is made about *Biscay*. It is a fine sort of Steel, but some of it is very difficult to work at the Forge, because it will not take a good Heat; and it sometimes proves very unsound, as not being well *curried*, that is well wrought. It is too quick (as Workmen call it) that is, too brittle for Springs or Punches, but makes good fine Edg'd-tools.

Venice-steel is much like *Spanish-steel*, but much finer, and Works somewhat better at the Forge. It is us'd for Razors, Chirurgion's Instruments, Gravers, &c. Because it will come to a fine and thin Edge. Razor makers generally clap a small Bar of *Venice-steel* between two small Bars of *Flemish-steel*, and so Work or Weld them together, to strengthen the back of the Razor, and keep it from crack-
ing.

There is another sort of Steel, of higher commendations than any of the forgoing sorts. It is call'd *Damascus-steel*; 'tis very rare that any comes into *England* unwrought, but the *Turkish-Cymeters* are generally made of it. It is most difficult of any Steel to Work at the Forge, for you shall scarce be able to strike upon a Blood-heat, but it will *Red-scar*; infomuch that these *Cymeters* are, by many Workmen, thought to be cast Steel. But when it is wrought, it takes the finest and keeps the strongest Edge of any other Steel. Workmen set almost an inestimable value upon it to make Punches, Cold-punches, &c. of. We cannot learn where it is made, and yet as I am inform'd, the Honourable Mr. *Boyl* hath been very careful and industrious in that enquiry; giving it in particular charge to some Travellers to *Damascus*, to bring home an Account of it: But when they came thither they heard of none made there, but were sent about 50 Miles into the Country and then they were told about 50 Miles farther than that: So that no certain Account could be gain'd where it is made. *Kirman* towards the Ocean affords very fine Steel, of which they make Weapons highly priz'd; for a *Cymeter* of that Steel, will cut through an Helmet with an easie blow. *Geog. Rect. fol. 279.*

The Rule to know good Steel by.

Break a little piece of the end of the Rod, and observe how it breaks; for good Steel breaks short of all Gray, like frost work Silver. But in the breaking of the bad you will find some veins of Iron shining and doubling in the Steel.

Of Nealing of Steel.

HAVING chose your Steel and forg'd it to your intended shape, if you are either to File Engrave or to Punch upon it, you ought to Neal it first, because it will make it softer and consequently work easier. The common way is to give it a *Blood-red-heat* in the Fire, then take it out, and let it cool of it self.

There are some pretenders to know how to make Steel as soft as Lead; but so oft as my Curiosity has prompted me to try their pretended Processes, so oft have they fail'd me; and not only me, but some others, careful Observers. But the way they most boast of, is the often heating the Iron or Steel in red-hot Lead, and letting it cool of it self with the Lead. I have many times try'd this without any other success, than that it does make Iron or Steel as soft as if it were well Neal'd the common way, but no softer: And could it be otherwise, the small Iron Ladles, that Letter-founders use to the casting of Printing Letters, would be very soft indeed; for their Iron Ladles are kept constantly Month after Month in melting Mettal, whereof the main Body is Lead, and when they cast small Letters, they keep their Mettal red-hot; and I have known them many times left in the Mettal and cool with it, as the Fire has gone out of it self; but yet the Iron Ladles have been no softer, than if they had been well Neal'd the common way. But perhaps these Pretenders mean the Iron or Steel shall be as soft as Lead, when the Iron or Steel is red-hot; if so, we may thank them for nothing.

But that which makes Steel a very small matter softer than the common way of Nealing is, by covering Steel with a course Powder of Cow-Horns, or Hoofs, or Rams-Horns, and so inclosing it in a Loam: Then put the whole Lump into a Wooden Fire to heat red-hot and let it lie in the Fire till the Fire go out of it self, and the Steel cool with the Fire.

Of Hardning and Tempering Steel.

E*English, Flemish and Swedish-steel*, must have a pretty high heat given them, and then suddenly quench in Water to make them very hard; but *Spanish and Venice-steel* will need but a Blood-red-heat, and then when they are quenched in Water, will be very hard. If your Steel be too hard, that is to brittle, and it be an edg'd or pointed Instrument you make, the edge or point will be very subject to break; or if it be a Spring, it will not bow, but with the least bending it will snap assunder: Therefore you must *let it down* (as Smiths say) that is, make it softer, by *tempering* it: The manner is thus, take a piece of Grin-stone or Whet-stone and rub hard upon your Work to take the black Scurf off it, and brighten it; then let it heat in the Fire, and as it grows hotter you will see the Colour change by degrees, coming to a light goldish Colour, then to a dark goldish Colour, and at last to a blew Colour; choose which of these Colours your Work requires, and then quench it suddenly in Water. The light goldish Colour is for Files, Cold-chissels and Punches, that Punch into Iron and Steel: The dark goldish Colour for Punches to use on Brass, and generally for most Edge-tools: The blew Colour gives the Temper to Springs in general, and is also us'd to Beautifie both Iron and Steel; but then Workmen some-
times

times grind *Indico* and *Sallad-oyl* together, and rub that mixture upon it, with a woollen Rag, while it is heating, and let it cool of it self.

There is another sort of *Hardning*, call'd *Hammer-hardning*, It is most us'd on Iron or Steel Plates, for *Dripping pans*, *Saws*, *Straight-Rulers*, &c. It is perform'd only, with well Hammering of the Plates, which both smooths them, and beats the Mettal firmer into its own Body, and somewhat hardens it.

The manner of Forging Steel, either for Edge-tools, Punches, Springs, &c. Is (the several shapes consider'd) the same with forging Iron: Only this general Rule observe, from an old *English Verse* us'd among Smiths, when they Forge Edge-tools,

*He that will a good Edge win,
Must Forge thick and Grind thin.*

The End of Smithing.