

*Sugar* dissolved like Salt kills them also, if used in the same manner, and with that some dye flat, and some dye round.

*Sack* will kill them, but not so speedily as the other Liquors. If I had had time, I might have set down many more Observations of this kind, to shew the Sensibility of these, and such like *Animalcula*.

IV. *The manner of making Steel, and its Temper; with a Guesß at the way the Ancients used to Steel their Picks, for the cutting or hewing of Porphyry. Communicated by Martin Lister, M. D. and S. R. S.*

IN the Philosophical Transactions, Numb. 93. p. 6015. amongst other Desiderata's and Queries, are these: *To endeavour to retrieve the Art of Hardning and Tempering of Steel, for cutting of Porphyry, &c.* We know not which way to rough-hew Stones of that untractable hardness.

Those famous and stupendious Monuments of Antiquity, the *Ægyptian* Obelisks are of *Porphyry*, and most of them curiously Carved with a vast number of Figures, one way of Writing of the Ancient *Ægyptians*: These Witness the Facility that Nation had of graving in *Porphyry*; a Stone which no Tool will now touch, nor nothing less affect, than Emery or Diamant Powder.

Mr. Ray assures us, That all the Obelisks of *Rome*, that are Graven with Hieroglyphicks, are of one and the same kind of Stone, *viz.* a Marble of a mingled Colour, Red and White, very hard, and hath not in so many Ages suffered the least by the Weather.

Some

Something there is certainly lost in this Age, as to the manner of *Steeling of Tools*: I should be glad, if by any Conjecture of mine, I could help to extricate and retrieve it.

To this Purpose, let us first see what Steel it self is, and how made: and then we shall best guess at the applying of it, in the making of Tools.

As for the moderns, there is great abuse in this Manufacture, and the Processes now used by most Nations, are fraudulent, and a poisoning of Iron, by certain Mineral Salts, rather than a true making of Steel.

The most Ancient Account, is that which is given us by *Aristotle, Meteorologicor. l. 4. c. 6.* which yet is very obscure and imperfect. The Passage is this; *Wrought Iron it self may be cast so, as to be made Liquid, and to harden again. And they are wont to make Steel thus: For the Scoria of Iron subsides, and is purged off by the bottom. And when it hath been often defecated and made clean, this is Steel. But this they do not often, because of the much wast, and for that it loses much Weight in fining. But Iron is so much the more excellent, the less Excrement it hath. Thus far Aristotle.*

This Account is a little confused, and not well understood: It is indeed true, That Iron is still better, the more it is purged. So in our Furnaces in *England*; those Bars which are wrought out of a Loop, taken up out of the Finney Harth, or second Forage, are much better Iron than those which are made in the Bloomary or first Harth, because those are more purged of the Dross, and accordingly give double Price.

Also, it is as true, that even wrought Iron may be melted as oft as you please.

Again, Iron, as oft as it is melted and purged, looseth much of its Weight. But after all, Iron of it self, how oft soever it is purged and refined, it will never become  
Steel;

Steel; yet of this so purged, the best Steel doubtless may be made.

And this is the most favourable Construction that I can make of this Passage of *Aristotle*.

In the next place, we shall give you the best account how *true Steel* is made at this Day, waving all fraudulent processes. The manner is this, faithfully described by *Agricola* (*de re Metallica, lib. 9.*) And to confirm to you the Antiquity of it; this way of making Steel is by *Kircher* said to be now in use in the Island of *Ilva*, a place famous from all Ages, even from the times of the *Romans*, for that Metal alone, down to our Days.

‘ Make choice of Iron which is apt to melt, and yet  
 ‘ hard, and yet which may easily be wrought with the  
 ‘ Hammer: For although Iron, which is made of Vitri-  
 ‘ olick Ore, may melt, yet it is soft, or fragil, or eager.  
 ‘ Let a Parcel of such Iron be heated red hot, and let  
 ‘ it be cut into small Pieces, and then be mixt with that  
 ‘ sort of Stone which easily melts; then set in the Smiths  
 ‘ Forge or Harth, a Crucible, or Dish of Crucible Metal,  
 ‘ a Foot and a half broad, and a Foot deep; fill the Dish  
 ‘ with good Charcoal, and compass the Dish about with  
 ‘ loose Stones, which may keep in the Mixture of Stone,  
 ‘ and Pieces of Iron put thereon.

‘ As soon as the Coal is throughly kindled, and the  
 ‘ Dish is red hot, give the Blast, and let the Workman  
 ‘ put on, by little and little, all the Mixture of Iron and  
 ‘ Stone he purposes.

‘ When it is melted, let him thrust into the middle of  
 ‘ it 3 or 4, or more Pieces of Iron, and boil them there-  
 ‘ in 5 or six Hours, with a sharp Fire; and putting in  
 ‘ his Rod, stir often the melted Iron, that the Pieces of  
 ‘ Iron may imbibe the smaller Particles of the melted Iron,  
 ‘ which Particles consume and thin the more gross Parti-  
 ‘ cles of the Iron Pieces; and are, as it were, a Ferment  
 ‘ to them, and make them tender.

‘ Let

‘ Let the Workman now take one of the Pieces out of  
 ‘ the Fire, and put it under the great Hammer to be  
 ‘ drawn out into Bars, and wrought, and then hot as it is,  
 ‘ forthwith plunge it into cold Water.

‘ Thus Tempered, let him again Work it upon the  
 ‘ Anvil and break it; and looking upon the Fragments,  
 ‘ let him consider whether it look like Iron in any part  
 ‘ of it, or be wholly condensed, and turned into Steel.

‘ Then let the Pieces be all wrought into Bars; which  
 ‘ done, give a fresh Blast to the Mixture, adding a little  
 ‘ fresh Matter to it, in the room of that which had been  
 ‘ drunk up by the Pieces of Iron; which will refresh and  
 ‘ strengthen the remainder, and make yet purer, the Pieces  
 ‘ of Iron again put into the Dish: every which Piece, let  
 ‘ him as soon as it is red hot, beat into a Bar upon the An-  
 ‘ vil, and cast it hot as it is into cold Water. And thus I-  
 ‘ ron is made into Steel; which is much harder and whiter  
 ‘ than Iron.

Being now certain what Steel is, and how it is to be distinguished and differs from Iron. In the last place, we will consider, if yet any thing can be found in the Ancients, which may hint to us any defect in our Tools, and how that may be remedied.

There is but one place that I know of to this purpose, which may give us any light in our Enquiry; and that is in *Pliny*, (*lib. 34. c. 14.*) where speaking of Iron, he says, *Fornacum maxima differentia est: in iis equidem Nucleus ferri excoquitur ad indurandum aliter, alioque modo ad densandas incudes malleorumve rostra.*

From this Passage it should seem, that the Ancients had one way to make Steel, and another way to harden or temper their Tools, particularly such as Picks and Anvils.

Also it is plain, That *Nucleus Ferri* was melted down in both.

Again

Again, the difference was in the Furnaces, that is, in the manner of ordering of the Iron to be made into Steel, or for the superlative hardning of the Heads and Bitts of Tools, and not in the Matter of which they were made; for both was done by excocting them in molten Iron.

I suppose none will doubt, but by *Nucleus Ferri*, must be meant well purged Iron; the same which *Aristotle* calls *εἰργασμένον σέδηρον*: For why else should he tell us that Wrought Iron it self may be made Liquid, so as to harden again; that is, according to our Phrase, cast again into Sow-metal, if it was not to explain to us the manner of making of Steel; which yet plainly is his design. It remains then, that we shew the different manner or use of this Liquid Iron; and we have no other light in this matter, but what two different Phrases afford us, *viz. ad indurandam Aciem*, and that of *ad densandos incudes malleorumve rostra*.

The first difference then, in my Opinion, is to be understood, of making Steel Bairlic; which they did probably after the Precept above delivered; that is, not only boil the Iron in its own Sow metal, or Liquid Iron, but hammer it also, and after quench it in cold Water.

And this Opinion those other Words of *Pliny* in the next Chapter favour, *Ferum accensam igni, nisi duretur ictibus, corrumpitur*: And again, *aquarum summa differentia est, cui subinde candens immergitur*. And this way was sufficient for Sword-Blades, and Knives, Razours, &c.

The other difference is in the Steeling their Tools: that is, they boiled their Tools in Sow-metal, to such a degree of Hardness or Temper, as was requisite, and did not afterwards hammer them. And this seems to be implied in the Phrase *Densare*, for indeed, altho' it generally be said, that Iron is purged and refined for

the making of Steel, yet according to the last and truest Process, the matter is plainly otherwise; for Iron this way made into Steel, becomes a kind of *Electrum*, and is filled with an exceeding brittle and hard Body of its own Nature; Iron being spungy and not close; for which purpose the refore, the Word *densare* is by *Pliny* aptly and elegantly used. And this way was used when the strongest temper and hardness was required; as to Picks and Anvils.

There might be divers reasons given for this last usage; as first, that there is far greater ease in working Iron, than Steel into any Figure, that being far softer and more ductible and loose.

Again, it is certain, and the Ancients in the passage last quoted do testify as much, that Iron by ignition is spoilt or corrupted, so that the oftner it is purged, tho' it were Steel it would the more relent. Whence knowing well, that in making their Tools out of Steel, they could not but considerably loose it and abate of their temper; they therefore first shaped them, and then gave them a strong Body of Steel and Temper together, and so had nothing else to do but to finish them on the Grindstone and Hone, to set the point or edge.

*V. The Descriptions of certain Shells found in the East Indies, Communicated by Mr. Witzen to Dr. Lister, and by him to the Publisher, with some Remarks of his own.*

S I R,

I Here sent you inclosed an Account of certain Shells and their Figures, which I received from Mr. *Witzen*, formerly Ambassadour here from the States of *Holland*, and