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I have been more full than any preceding writer; and, I hope, with a judgment that will rescue this science from the darkness with which it was enveloped. The second chapter contains an account of the methods of Streaming in its present improved state. This immediately follows the chapter on Shoding, because of its near affinity to that subject. The practical part of Shoding and Streaming is founded upon a belief of the Noachian deluge and its effects, which are incontestably verified in Shode and Stream works. In the third chapter, the effectual working of a Mine is exhibited in the sinking of Shafts, driving Adits, digging and raising of Ores, drawing the water, and every other operation under-ground. This is intended to explain the several parts of a Mine, and their dependency on each other; and to evince that such contingencies must be in all Mines, although varied in their situations according to the different circumstances of different Mines. To this is added, a parallel section of the greatest Mine now at work in Cornwall, to illustrate the whole. The chapter following relates to the management of a Mine when in a proper course of working; wherein such maxims are laid down, that a novice in conducting a Mine may understand some matters indispensably connected with that art. The last chapter of this book treats of Damps, Dialling, and Levelling, with practical instances and remarks, supported by experience, and altogether necessary.

The fourth book treats of the several manuductions used in dressing of Tin, Copper, and Lead Ores, and contains some brief remarks upon dressing Gold, Silver, &c. Though the general manner of dressing Copper Ore was first taken from the methods used in the Lead Mines, yet there are so great a variety of Copper Ores requiring very opposite treatment in their dressing, that I hope the subject will be found greatly improved. The dressing of Tin is indeed an art confined to the stannaries only; yet the curious delicate manner in which it is manufactured in the dressing, may furnish many improvable and beneficial hints for the cleansing of other Minerals from their sordes. I have been very accurate in describing the manner of dressing Tin Ore, as I have had ample experience in that business; and I doubt not of its proving a useful and general standard in that branch of Mineralogy.

The beginning of the fifth book consists of a memoir upon assaying, and more particularly upon a part of the Docimastick art, which has never been so experimentally treated of before,

viz.

viz. How to aſſay Mundicks and Tin for Gold or Silver; by which proceſſes the curious may judge how far the Mundicks of one place are ſuperior to thoſe of another for the precious Metals, or whether they contain any Silver or Gold. The proceſſes for aſſaying Copper Ores by calcination, and by the regule way, are both infallible, if the operator will be attentive to his buſineſs. Theſe proceſſes are little known out of the Corniſh aſſay offices, and have been too long kept profoundly ſecret, for purpoſes which the reader will readily comprehend. The method of aſſaying Tin Ore is very ſimple and efficacious, from the eaſy fuſibility of its Metal. An adept in trying Copper Ores will ſoon know how to manage in aſſaying Cobalt, by the mode preſented to his view in this chapter.

The laſt and grand object, is the manufactory of Tin and Copper Ores into their reſpective Metals; and I have ſet forth, as ſuccinctly and clearly as the materials I have obtained would allow, the proceſſes of ſmelting and metallizing thoſe products, without infringing too much upon the ſecrets of private trade. And though I have not forgotten to point out the oppreſſions of monopoly, yet it is with leſs ſeverity than is due to the magnitude of the evil, and its miſchievous effects.

The Appendix treats of the great improvement in the ſteam fire engine by Mr. Watt; an invention of more conſequence to the Mining intereſt of Great-Britain, than any diſcovery that has been made for half a century; and I hope to ſee its univerſal uſe eſtabliſhed in a very ſhort time.

As the idioms and terms of Corniſh Miners are moſtly derived from the ancient Corniſh Britiſh dialect, and therefore not eaſily intelligible to gentlemen unaccuſtomed to Mining, who may have occaſion to converſe or correſpond with them; to prevent miſconception, I have ſubjoined an explanation of thoſe terms in alphabetical order, including the relation they bear to thoſe of the Lead Mines and Collieries.

and dressed fit for smelting, at the rate of a shilling out of the pound, in the price it sells for; nay I have known an instance of its being done for ten pence. In this case, the end or stool of the vein will run of itself, like sand, against the workman with the use of his shovel only. This Ore generally lies shallow; and seventy years ago, when Copper was not searched for and little known among us, the Tinners threw it into the rivers as refuse, by the name of Poder, which signifies dust, Mundick, or waste. After it became well known, and was wrought for sale, it seldom exceeded £3 10s. ℔ ton for several years, while there were but one or two purchasers.

Red Copper Ore is rather scarce, but it is valuable. There is a kind of red, steel grained, gossany Ore, that looks very rich, and is worth from £14 to £20 ℔ ton, according as it is impregnated with Gal or Iron, which renders it harsh and stubborn for smelting. But of all Copper Ores, that which goes by the name of Peacock Ore, far surpasses the rest for beauty and elegance of tint, while it is new and fresh; for after it has been long exposed to the salts of the atmosphere, its beautiful colour fades away. The interior of this is yellow.

Of yellow Copper Ore, I have observed four sorts in general. The first is found shallow among black Ore, small, or not in large rocks; and it can be freely scraped into a yellow dust of a rich appearance. The second is the fine gold coloured flakey Ore, that is rich to the eye and in the crucible; its real value may be from £12 to £15 ℔ ton: it is this kind of Ore which shoots into distinct and regular tetrahedrons, geometrically defined a triangular pyramid of four equilateral triangles: they are always small, distinct, regular, and of the highest polish; are very common, and as commonly overlooked by the superficial observer. The third is a perfect brass coloured Ore, which rises in great quantities, and is reckoned the best colour of any for its continuance in the Mine: when this comes up in plenty, the Miners please themselves with the sight of it for that reason, although the value may be not more than from £7 to £10 ℔ ton. This coloured Ore seldom rises before the vein is sunk fifty fathoms deep, or at least not in great heaps; the richer or more inconstant Ores being superincumbent. But the fourth and deepest Copper Ore is of a pale yellow, pretty much corrupted with Mundick, and of an inferior price, being from £4 to £6 ℔ ton. The superior quantity, however, recompences for its quality and charges of dressing; for it is not which contain a volatile animal Salt; and being ſo cemented, they quench it in water, whereby its pores are ſo greatly conſtringed, that it immediately grows ſo hard as to acquire the properties of Steel.

Of all the ſubſtances concurring to form the terreſtrial globe, Iron ſeems to have the greateſt ubiquity; as it is well known to enter into the compoſition of Earth, Stone, Plants, and Animals, ſo truly, that from the aſhes of either you may viſibly and ſenſibly perceive its exiſtence, even ſo as to be diſcovered in various ſecretions from human blood, in milk, urine, fat, &c. as may be proved by drawing a Loadſtone (whoſe property it is to attract Iron only) over their calx, aſhes, or reſiduum, when the Iron particles will be drawn out of them, and adhere to the Magnet.

Iron is the moſt uſeful to human life: it is our defence and ſecurity; and no arts or manufactories could exiſt without it. Navigation, trade, and commerce, would be at a ſtand; and even the art of diſcovering other Mines and Metals, could not be practiſed without it: ſo that this, which is conſidered as the baſeſt of Metals, is indiſpenſably neceſſary for all the various uſes of mankind. Beſides the innumerable kinds of inſtruments made of it, it furniſhes excellent remedies in many diſeaſes: by its figure and gravity with the human blood, it becomes a deobſtruent and reſtorative in cold and relaxed temperaments; but in full and ſanguine habits, it is inflamatory and dangerous, unleſs preceded by veneſection and other evacuations.

Tin, Stannum; Jupiter. טין in the Chaldee ſignifies ſlime, mud, or dirt; and when the Phenicians came into Cornwall, and ſaw this Metal in its ancient ſlimy ſtate, they called it, "The Mud:" from thence the name, Tin, (in Cornu-britiſh Stean, in Latin Stannum) has proceeded, and is ſtill continued. Some of the ancients called it Plumbum Album, White Lead, to diſtinguiſh it, perhaps, from common Lead. It was by them called White Lead, from its colour and purity; but they did not know it to be, radically, another Metal. We find no Latin name in authors for the Ore of Tin; probably, becauſe the ancients were unacquainted with it as a Metal characteriſtically diſtinct from Lead. Neither do the Tinners or Miners call it Tin Ore; for they give it the name of Tin-ſtuff, as it riſes out of the earth; and they diſtinguiſh it by ſeveral incidents which happen often to it, either from the Ores, or crude Minerals

intermixing

Lode-ſtones, extremely ſmall; ſometimes veined in the Stones, and branchy throughout the Lode, whereby it may be ſeparated and ſorted as it riſes, to the ſaving of much expence in dreſſing: in other places it may be priany, peachy, flookany, or mundicky, with which it may be either very prevalent or ſcanty; but in the latter, and where Copper participates, it muſt be well burnt before the true value of it can be known.

This Metal ſeems to be earthy and very ſulphureous; almoſt ſoft and pliable as Lead, but more white and beautiful. Bend a piece of pure Tin, or bite it hard, and it will give a craſhing noiſe or ſtridor; but its purity is beſt known by obſerving the whiteneſs or delicacy of its grain, when broke off ſhort. Tin, like Lead, is more eaſily diſſolved in a weak acid menſtruum, than in a ſtrong one. It may be eaſily amalgamated with Quickſilver, and melts almoſt as readily as Lead; therefore, it will not bear ignition. It is not naturally very ſonorous; but becomes ſo, when properly commixt with Copper. It will not eaſily endure the teſt by fire; for as ſoon as the heat becomes violent it aſſumes the form of a ſtubborn aſh or calx, which ſoon loſes its fluidity, and is changed into a powder called Putty; which powder is alſo made by calcination of Tin, but is reducible into Tin again by melting with a proper flux.

Beſides its uſefulneſs in utenſils per ſe, it is alſo neceſſary for covering the inſide of Copper, Braſs, and Iron veſſels, to preſerve them wholſome for culinary uſes; whence there is a large conſumption for tinning Braſs ware and the like: it is uſeful alſo in ſoldering; but I believe the compound Metal of Pewter, of which it is the principal ingredient, is preferable for that purpoſe. Beſides its domeſtick uſes, it is a neceſſary article, when diſſolved in Aqua Fortis, for the new ſcarlet or Bow die. And if I am rightly informed, our moſt beautiful and laſting coloured fine cloths owe their ſuperlative excellency to the retentiveneſs given by our fineſt grain Tin; inſomuch, that the Engliſh ſuperfine broad cloths, dyed in grain by the help of this ingredient, are become famous in all markets of the known world.

It is more than probable, that the purple die of the Tyrians gained the very great reputation it had among the ancients, in great part, if not wholly, from their uſe of our Tin in the compoſition of their die-ſtuff, as the Tin trade was ſolely in their own management and direction. I think the known facts of its being their monopoly, the exceeding usefulness of it as one of the non-colouring retentive ingredients, and the fame in all parts of the world of the unfading colour of that purple which is supposed to be given by the juice or saliva of a certain shell fish called Purpura, do very much preponderate towards my conjecture.

We may be certain, that almost the sole traffick to this island four and twenty centuries ago, was for this Metal; and we have before observed, that in those very early ages, our Tin was sold to the Phenicians, who (like the present Hollanders, the grand carriers of Europe) transported the commodity in their bottoms to all foreign parts. " Tyrus, O thou that art situate at the " entry of the sea, which art a merchant of the people for " many isles." (Ezekiel).

Jesus the son of Sirach, the author of Ecclesiasticus, lived 247 years before Christ. In speaking of Solomon's glory, chap. xlvii. vers. 18, he says, " By the name of the Lord God, " which is called the Lord God of Israel, thou didst gather " Gold as Tin, and didst multiply Silver as Lead." Which shews that Tin in those days, viz. 247 years before Christ, was exceedingly plenty in the Holy Land. And it is remarkable, that Tin and Lead in this place, are both mentioned, and distinguished; so that the latter cannot be taken or meant for the former, as they have been mistaken and confounded together for one Metal by others, though characteristically different. By the ships Solomon sent out, he had a return in one voyage only, of no less than 420 talents of Gold; therefore it is expressed, 1 Kings x. 27. " Money was in Jerusalem as Stones " for plenty." How vastly plentifull must Tin have been then in Jerusalem, to be spoken of in the above figurative way?

We cannot, however, say positively, that no other country produced this Metal in those days; but if it was then known in other nations, it was very little sought after, and was estimated as a staple by no country except Cornwall. Pliny says, it was found in Gallicia and Lusitania, but not at a depth or in quantity to merit much attention. A Tinner, in the time of Richard earl of Cornwall and king of the Romans, upon some disgust at home, went over to Saxony, and taught the natives to seek for Tin, and render it merchantable: they have to this day ſome workings for Tin, though of no further account, than for their own conſumption. Alonzo Barba, ſays, that they had rich veins of Tin at Oruro and Potoſi; but their vicinity to ſuch immenſe Mines of Silver, is the reaſon of their being never worked to any purpoſe. A great deal of Tin has been imported into Europe theſe latter years from the Moluccas, ſome bars of which the writer has ſeen equal to the beſt Corniſh Grain Tin.

BOOK

BOOK II.

CHAP. I.

Of the Strata of the Earth, and the Fissures in which Metals are found, their Direction, Inclination, or Underlie.

BEFORE we discover the recesses of our Metals and Minerals, it will be convenient for the reader to have some knowledge and acquaintance with the circumjacent Strata, which enclose the objects of our enquiry: pursuant, therefore, to the plan of a late ingenious author, upon our entrance on the subject before us, we will examine the shell first, and then consider the kernel.

The Strata of different countries are various; and from enquiry I cannot find that they are influenced by the atmosphere or climate in any degree: and they are not only various, but alternate in their extent, breadth, and depth, in all parts of the world. In the Mining countries, they are found of different densities and gravity, Stratum super Stratum throughout; some hard, some soft, then hard and soft again. Thus we may find uppermost, a Stratum of Granite, or Moorstone-rock; then a softer Granite, called Grouan; now Kellas; and so on, to the concave of the grand abyss. Half a mile distant, the layers of Rock or Stone will be altogether changed in their positions or complexions; whereby no absolute rule can be formed, to decide upon the certainty of meeting with this or that Stratum, before the industrious Miner has laid them open to view.

I shall not attempt to describe all the Strata that are to be met with; but shall confine myself to Cornwall, and even that part of it which is disposed for Metal, within compass of my own personal inspection.

The general law of attraction evidently appears in the distribution of our Strata; and their specifick gravities seem not to determine them so much as might be expected: whence we

may

tion north, and ſouth, contrary to the metallick veins, which generally keep their courſe through it, but the Lodes are frequently ſqueezed up by its accompanying them ſome length in their courſe, or are ſplit into many ſmall branches. Sometimes the Fiſſures or Lodes are thrown ſhort on one ſide, out of their direct courſe as it were, by the extreme hardneſs of this Stratum, and afterwards they recover their courſe again. At other times the metallick veins are elevated or depreſſed by it, though they always recover their former direction, and unite again; for this Stratum wears out at a great depth, and is ſucceeded by Killas.

Moorſtone or Granite. The name of Granite, which theſe Strata have univerſally obtained, is a modern name given them by the Italian writers, on account of their being concreted into grains, or in a granulous ſtructure, and not compact and uniform as the Marbles, &c. are; thence Granita i. e. è granis compoſita. The parts of Granite are not homogeneous, but are different concretions of Quartz and Micæ. The varieties are compoſed of black and white Talc, a dead earth not unlike the white Boles or Pipe Clay, and true Cryſtal.

We have five ſorts common to us, viz. the white, the dove coloured, the yellow, the red or Oriental Granite, and the black or true Corniſh N° 1 of Hill. Either of theſe as a Stratum, is called a Hard Grouan Country, (in the Swediſh tongue Graberg, and Graſten) and the two laſt are frequently ſo hard and invincible as to tire the patience and pocket of the adventurers, and the labour of the workmen. Grouan Strata are diſpoſed for Tin, which in ſuch ſituations is generally of a rich quality, or cannot long be ſought after or wrought in its almoſt impregnable walls. They are ſeldom likely for Copper Ore; and were long thought to be wholly adverſe to that Mineral, till the great Mine of Treſavean proved that rule exceptionable.

The Ire-ſtone, or Iron-ſtone, is by much the hardeſt of all Strata, and borrows this name from its extreme hardneſs, and not becauſe it contains Iron. It is of a dark bluiſh colour, like Lead that has been long expoſed to the weather; and uſually ſo hard, that it muſt be wrought with Steel borers, and then blown by gunpowder. It often keeps a courſe eaſt and weſt like a Lode, but is commonly very wide; and therefore it is very tedious and chargeable, where an adit muſt be driven acroſs through it. It is this Stratum that is uppermoſt through great

part

and commerce and the ornaments of life) would be endless, and the expence of procuring exceed the value of the acquisition.

"These Fissures," says Agricola de Ortu, &c. "were the "channels through which the waters retired at the time of the "creation into the ocean, when the dry land made its first ap-"pearance:" and Woodward in his Nat. Hist. thinks they are breaches made in the Strata by the retiring waters of the deluge, prior to which æra (according to his hypothesis) there could be neither Fissure nor Lode. The opinion of the former is easily refuted; for the walls of the Fissures in some places are too hard to be overcome, and to yield to the power of any current of water; and in other places too fair and tender to endure the force of such a torrent: besides, their east and west direction, have not that tendency, in our parts, to discharge into the ocean, as they might seem to show, if their courses made for St. George's channel in the north, and the British channel in the south. With regard to the latter opinion, our Shodes will notoriously evince the mistake; as the Fissure must be antecedent to the matter of its contents, whose Shodes, it is generally believed, were separated from the superior part of the Lode by the retiring diluvium.

The inside of those Fissures are commonly glidered or coated over with a hard, crystalline, earthy substance or rind, which very often in breaking of hard Ore comes off with it, and is vulgarly called the Caples or Walls of the Lode: but I take it the proper walls of the Lode are the sides of the Fissure itself, and not this coat, which is the natural plaister upon those walls, furnished perhaps by the contents of the Fissures, or from oozings of the environing Strata. We can presently see the breadth of a Lode or of a branch, by the incrusted sides of the Stones of Ore, if brought whole to grass, although we were never under-ground to take the measure of it; therefore it is common to say, "I perceive the breadth of this or that Lode, "to be so many inches wide; because here are the smooth "walls or caples affixed to and broke off with the Stones of "Ore." But this can be only in small Lodes, and hard Strata, where the Lode breaks stoney. If a Lode is inclinable to yield any sort of Ore, it is the more promising provided the caples or walls of the Lode are regular and smooth, or at least if one of them is so; but if they are uneven and rugged, it is the less encouraging. There are, however, but few Lodes or Fissures that make regular walls, until they are sunk on a few fathoms.

Thus,

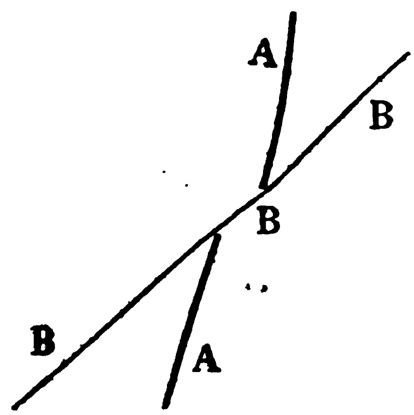
Thus, the medullary or inner part of a Fissure, in which the Ore lies, is all the way environed and bounded by two walls or coats of Stone, which are generally parallel to each other, and include the breadth of the vein or Lode; so that when the Miners dig down or along in a large Lode, then the roof, i. e. the upper, the hanging wall, or incumbent wall of the Lode or Fissure, is (in a certain proportion according to its inclination or underlie) over their heads; and the lower, or other wall or rind, is under their feet: and further, whatever angle of inclination some Fissures make at first in the firm solid Strata, they seldom vary from the same in depth: there are, however, some exceptions to this rule. Some Fissures are very uncertain and different in size; for they may be very small near the surface, or very wide in depth, and vice versa; but as to the regular breadth or largeness of Lodes in their length or direction, they generally make a great variation; for although a Fissure may be many fathoms wide in one particular place, yet, a little further east or west, it may not perhaps be an inch wide.

This variation may happen from several causes, but more especially in very compact Strata, when the Lode or Fissure is squeezed, as it were, through means of hard rocks, which seem to compress and straiten the Fissure. However, a true Lode, Course, or Fissure, is never entirely cut out or destroyed by hard rocks or Strata; for the Fissure always continues through the hardness, yielding a rib or string of metallick Ore, or else of a veiny substance; which often serves for a leader for the Miners to follow, until it sometimes brings them again to a large and rich part of the impregnated Fissure: all which variety of size in the length, breadth, and depth of Fissures, shews that they are the immechanical operations of nature, to fix and settle different congeries of mixed bodies into their peculiar shapes and positions.

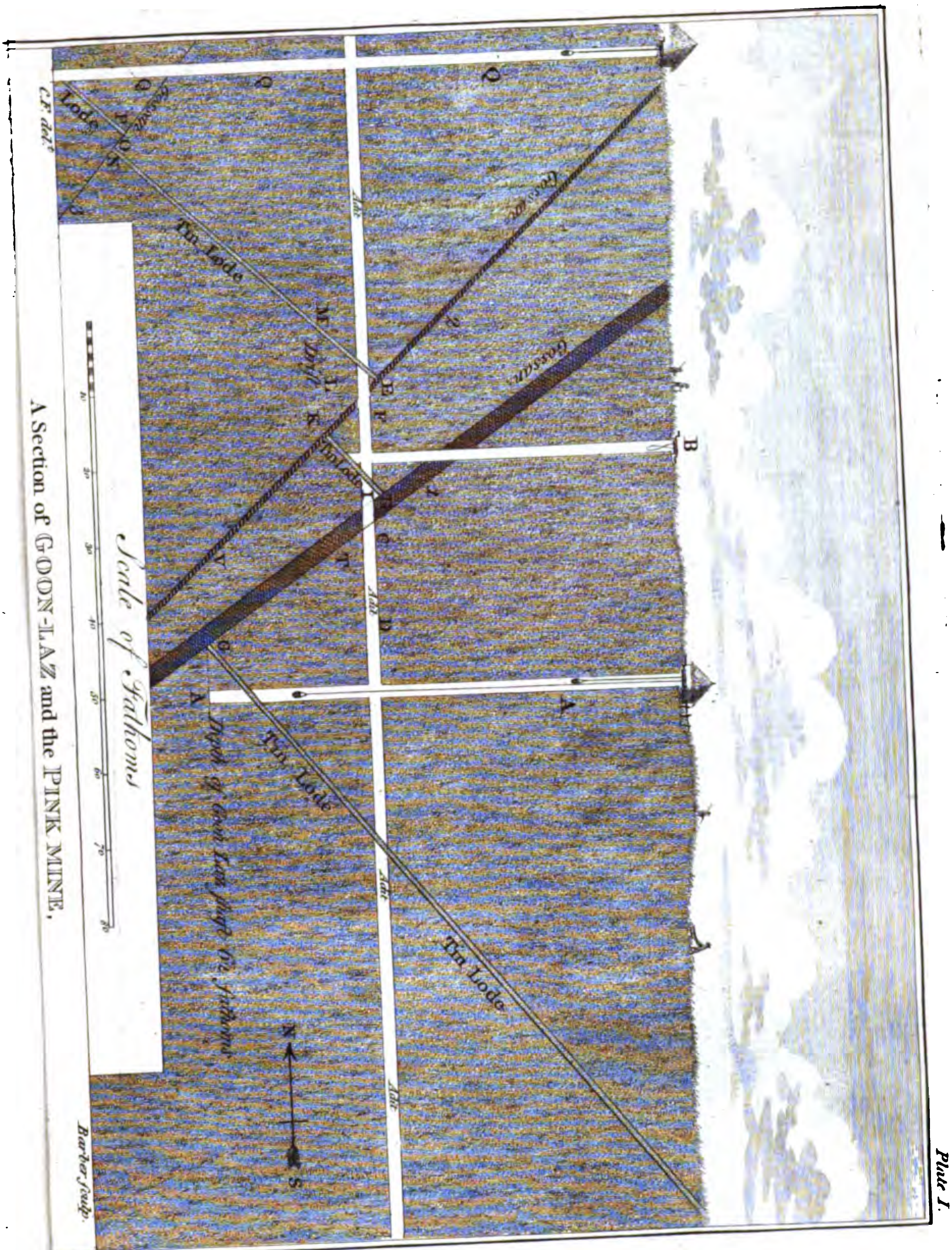
As to the length and depth of Fissures, perhaps they seldom admit of any period or limitation; for none can tell how long or how deep they reach: but in regard of their breadth, thickness, width, or largeness, they are limited and various. Though the depth of Fissures is unlimited beyond the power of man to follow after, yet it appears in general, that their fruitfulness for Metal is distinct and limited. The richest state for Copper is between forty and eighty fathoms deep, and for Tin between twenty and sixty; and though a great quantity may be raised of either at

fourscore

diſtance. Let A A repreſent the true or metallick Lode, and B B B the Slide, and the fracture and remove will be ſeen at one glance; whence the reader may judge for himſelf, how expeditiouſly and certainly the metallick Lode may be recovered.



BOOK



A Section of GOON-LAZ and the PINK MINE,

and
... happened an earthquake, which cleaved the earth, and diſcloſed a vaſt profuſion of Silver.
This

BOOK III.

CHAP. I.

Of the various Methods of diſcovering Mines.

LUCRETIUS, who aſcribes the firſt diſcovery of Metals to the burning down of woods, ſays, that the heat of the flames melted the Metals, which were diſperſed here and there in the veins of the earth, and made them flow into one maſs:

Whatever 'twas that gave theſe flames their birth,
Which burnt the tow'ring trees, and ſcorch'd the earth;
Hot ſtreams of Silver, Gold, and Lead, and Braſs,
As nature gave a hollow, proper place,
Deſcended down, and form'd a glitt'ring maſs.
This when unhappy Mortals chanc'd to ſpy,
And the gay colour pleas'd their childiſh eye;
They dug the certain cauſe of miſery.

Cadmus, the Phenician, is, by ſome, ſaid to have been the firſt who diſcovered Gold; others ſay, that Thoas firſt found it, in the mountain Pangæus in Thrace: the Chronicon Alexandrinum, aſcribes it to Mercury, the ſon of Jupiter; or to Piſus, king of Italy, who quitting his own country went into Egypt; where, after the death of Miſraim, the ſon of Cham, he was elected to ſucceed him in the royal dignity, and, for the invention of Gold, was called the Golden God. Æſchylus attributes the invention of this, and all other Metals, to Prometheus: and there are others who write, that either Æaclis, whom Hyginus calls Cæacus the ſon of Jupiter, or Sol the ſon of Oceanus, firſt diſcovered Gold in Panchaia. Ariſtotle ſays, that ſome ſhepherds in Spain having ſet fire to certain woods, and heated the ſubſtance of the earth, the Silver that was near the ſurface of it, melted, and flowed together in a heap; and that a little while after there happened an earthquake, which cleaved the earth, and diſcloſed a vaſt profuſion of Silver.

This

of a young man, and again to his former appearance: Circe alſo changed the companions of Ulyſſes into beaſts, and again reſtored them to the human ſhape; and Mercury, with his rod called Caduceus, gave ſleep to the wakeful, and awakened thoſe that were aſleep. And hence, in all probability, aroſe the application of the forked rod to the diſcovery of hidden treaſure.

Nevertheleſs we find no mention made of this Virgula before the eleventh century, ſince which it has been in frequent uſe. It was much talked of in France towards the end of the ſeventeenth century; and the corpuſcular philoſophy was called in to account for it. The corpuſcles, it was ſaid, that riſe from the Minerals, entering the rod, determine it to bow down, in order to render it parallel to the vertical lines which the effluvia deſcribe in their riſe. In effect the Mineral particles ſeem to be emitted from the earth: now the Virgula being of a light porous wood, gives an eaſy paſſage to thoſe particles, which are very fine and ſubtle; the effluvia then driven forwards by thoſe that follow them, and preſſed at the ſame time by the atmoſphere incumbent on them, are forced to enter the little interſtices between the fibres of the wood, and by that effort they oblige it to incline, or dip down perpendicularly, to become parallel with the little columns which thoſe vapours form in their riſe.

The primary and moſt ſimple affections of matter, according to the great Mr. Boyle, are (1) Local Motion, (2) Size, (3) Shape, and (4) Reſt. But becauſe there are ſome others, that naturally flow from theſe, and are, though not altogether univerſal, yet very general and pregnant, we ſhall ſubjoin thoſe which are the moſt fertile principles of the qualities of bodies, and other phenomena of nature. Thoſe leſſer fragments of matter, which we call corpuſcles or particles, have certain local reſpects to other bodies, and to thoſe ſituations which we denominate from the horizon; ſo that each of theſe minute fragments may have a particular (5) poſture or poſition, as erect, inclining, horizontal, &c. and as they reſpect us that behold them, there may belong to them a certain (6) order or conſecution, whereby we ſay, one is before or behind another; and many of theſe fragments being aſſociated into one maſs or body, have a certain manner of exiſting together, which we call (7) texture or modification. Almoſt all bodies, and thoſe fluid ones that are made up of groſſer parts, will have (8) pores in them: and very many bodies having particles, which, by their ſmallneſs,

ſmallneſs, or their looſe adherence to the bigger or more ſtable parts of bodies they belong to, are more eaſily agitated, and ſeparated from the reſt by heat and other agents; therefore there will be great ſtore of bodies, that will emit thoſe ſubtle emanations, which are commonly called (9) effluvia.

Each of theſe nine producers of phenomena, admit of a variety ſcarcely credible. For not to deſcend ſo low as inſenſible corpuſcles, (or thoſe which are imperceptible to natural or artificial opticks, many thouſands of them being requiſite to conſtitute the ſize of a muſtard ſeed) what an innumerable company of different bigneſſes may we conceive between the bulk of a mite, (a crowd of which is neceſſary to weigh one grain) and a mountain, or the body of the ſun! Figure, though one of the moſt ſimple modes of matter, is capable of great varieties, partly in regard of the ſurface or ſurfaces of the figured corpuſcles, (which may conſiſt of ſquares, triangles, pentagons, &c.) and partly in regard of the ſhape of the body itſelf, which may be either flat like a cheeſe, ſpherical like a bullet, eliptical like an egg, cubical like a die, cylindrical like a pump, hexagonal pointed like a pyramid, or conical like a ſugar loaf. And yet all theſe figures are few compared to thoſe irregular ſhapes, which are to be met with among rubbiſh, &c. So likewiſe motion, which ſeems ſo ſimple a principle, eſpecially in ſimple bodies, may even in them be very much diverſified; and as to the determination of motion, the body may move directly upwards, or downwards, declining, or horizontally, eaſt, weſt, north, or ſouth, &c. according to the ſituation of the impellent body. There will likewiſe ariſe new diverſifications, from the greater or leſſer number of the moving corpuſcles; from their following one another cloſe, or more at a diſtance, &c. from the thickneſs, thinneſs, pores, and the conditions of the medium through which they move; and from the equal or unequal celerity of their motion, and force of their impulſe: and the effects of all theſe are variable by the different ſituation and ſtructure of the ſenſories, or other bodies, on which theſe corpuſcles act.

Now there are, firſt, many bodies, that in diverſe caſes act not, unleſs they be acted on; and ſome of them act, either ſolely or chiefly as they are acted on by common and unheeded agents. Secondly, there are certain ſubtle bodies that are ready to inſinuate themſelves into the pores of any body diſpoſed to admit their action, or by ſome other way effect it. Thirdly, there are bodies, which, by a mechanical change of texture, may

may acquire or lose a fitness to be wrought upon by such unnoticed agents; and also to diversify their operations on it, upon the force of its varying texture. All these propositions are proved from the most common, though unheeded affairs and occurrencies of human life; as easily, as the polarity and magnetism of an old Iron bar taken from a church window, where it has stood upright for many centuries, is proved to derive its virtue from the magnetick effluvia of the earth.

As many deny, or at least doubt, the attributed properties of the divining rod, I shall not take upon me, singly to oppose the general opinion, although I am well convinced of its absolute and improveable virtues. It does not become me to decide upon so controvertible a point; particularly, as from my natural constitution of mind and body, I am almost incapable of cooperating with its influence; and, therefore, cannot, of my own knowledge and experience, produce satisfactory proofs of its value and excellence. I shall, however, give those accurate observations on the virtues of the Virgula Divinatoria, which I have been favoured with by my worthy friend Mr. William Cookworthy, of Plymouth, a man, not less esteemed for his refined sense and unimpeachable veracity, than for his chemical abilities. It is to him the publick is indebted for the late improvements in the porcelain manufactory now established at Bristol, which, under his direction, is likely to be rendered not less elegant and durable than the best Asiatick China.

His first knowledge of the rod, he says, was from a captain Ribeira, who deserted the Spanish service in queen Ann's reign, and became the capt. commandant in the garrison of Plymouth; in which town he satisfied several intelligent persons of the virtues of the rod by many experiments on pieces of Metal hid in the earth, and by the actual discovery of a Copper Mine near Oakhampton, which was wrought for some years. The captain made no difficulty to let people see him use the rod, but he was absolutely tenacious of the secret how to distinguish the different Metals by it, without which, the knowledge of its attraction is of little use: but by a close attention to his practice, the writer has discovered this, and made many other discoveries of its properties, which he is willing should be published, being fully persuaded of the great utility of this instrument in Mineral undertakings; and the reader may be assured, that he is fully convinced of the truth of what he communicates from abundant and very clear experience.

Captain Ribeira held, that rods cut from the nut or other fruit-bearing trees, were the only proper ones for this use; and that the virtue was confined to certain persons, and those comparatively few. Agricola says, "If the attractive power of veins does not "turn the rod, when in the hands of some particular metallists "or others, it is owing to some singular occult quality in the "holder, which impedes and restrains the attractive power; "for since that power moves and turns the rod, in the same "manner as the Lodestone invites and attracts Iron, it is "debilitated and destroyed by the occult quality in the holder, "just as garlick weakens and excludes the attractive quality of "the magnet, for a magnet rubbed over with juice of garlick "does not draw Iron." But this proves to be a mistake of captain Ribeira; for the virtue, as he calls it, resides in all persons, and in all rods, under the circumstances hereafter described.

The rod is attracted by all the Metals, by Coals, Bones, Limestone, and Springs of Water, with different degrees of strength in the following order: 1 Gold, 2 Copper, 3 Iron, 4 Silver, 5 Tin, 6 Lead, 7 Coals, 8 Limestone and Springs of Water. One method to determine the different attractions of the rod, is this: Stand, holding the rod, with one foot advanced; put a guinea under that foot, and a halfpenny under the other, and the rod will be drawn down; shift the pieces of money, and the rod will then be drawn towards the face or backwards to the Gold, which proves the Gold to have the stronger attraction. By trying all the subjects of the rod in the same manner, their respective attractions in point of strength will be found to correspond with the order in which I have already placed them.

The rods formerly used, were shoots of one year's growth that grew forked, as figures 1 and 2, plate 2; but it is found, that two separate shoots tied together with some vegetable substance, as packthread, will answer rather better than those which are grown forked, as their shoots being seldom of equal length or bigness they do not handle so well as the others, which may be chosen of exactly the same size. The shape of the rod thus prepared, will be between 2½ and 3 feet long, like fig. 3, plate 2. They must be tied together at their great or root ends, the smaller being to be held in the hands. Hazle rods cut in the winter, such as are used for fishing rods, and kept till they are dry, do best; though where these are not at hand, appletree ſuckers, rods from peach-trees, currants, or the oak, though green, will anſwer tolerably well.

It is very difficult to deſcribe the manner of holding and uſing the rod: it ought to be held in the hands, in the poſition fig. 4, plate 2, the ſmaller ends lying flat or parallel to the horizon, and the upper part in an elevation not perpendicular to it, but 70 degrees, as fig. 4, plate 2.

Alonzo Barba directs the rod to be fixed acroſs the head of a walking ſtick in form of a T, and the end which is neareſt the root will dip or incline to the Mineral Ore.

The rod being properly held by thoſe with whom it will anſwer, when the toe of the right foot is within the ſemi-diameter of the piece of Metal or other ſubject of the rod, it will be repelled towards the face, and continue to be ſo, while the foot is kept from touching or being directly over the ſubject; in which caſe, it will be ſenſibly and ſtrongly attracted, and be drawn quite down. The rod ſhould be firmly and ſteadily graſped; for if, when it hath begun to be attracted there be the leaſt imaginable jirk, or oppoſition to its attraction, it will not move any more, till the hands are opened and a freſh graſp taken. The ſtronger the graſp the livelier the rod moves, provided the graſp be ſteady, and of an equal ſtrength. This obſervation is very neceſſary, as the operation of the rod in many hands is defeated purely by a jerk or counter action; and it is from thence concluded, there is no real efficacy in the rod, or that the perſon who holds it wants the virtue; whereas by a proper attention to this circumſtance in uſing it, five perſons in ſix have the virtue as it is called; that is, the nut or fruit bearing rod will anſwer in their hands. When the rod is drawn down, the hands muſt be opened, the rod raiſed by the middle fingers, a freſh graſp taken, and the rod held again in the direction deſcribed.

A little practice by a perſon in earneſt about it, will ſoon give him the neceſſary adroitneſs in the uſe of this inſtrument: but it muſt be particularly obſerved, that as our animal ſpirits are neceſſary to this proceſs, ſo a man ought to hold the rod, with the ſame indifference and inattention to, or reaſoning about it or its effects, as he holds a fiſhing rod or a walking ſtick; for if the mind be occupied by doubts, reaſoning, or any other operation that engages the animal ſpirits, it will divert their powers from being exerted in this proceſs, in which their

instrumentality

instrumentality is absolutely necessary; from hence it is, that the rod constantly answers in the hands of peasants, women, and children, who hold it simply without puzzling their minds with doubts or reasonings. Whatever may be thought of this observation, it is a very just one, and of great consequence in the practice of the rod.

If a rod, or the least piece of one, of the nut bearing or fruit kind, be put under the arm, it will totally destroy the operation of the Virgula Divinatoria in regard to all the subjects of it, except water, in those hands in which the rod naturally operates. If the least animal thread, as silk, or worsted, or hair, be tied round or fixt on the top of the rod, it will in like manner hinder its operation; but the same rod placed under the arm, or the same animal substances tied round or fixt on the top of the rod, will make it work in those hands, in which, without these additions, it is not attracted.

The willow, and other rods, that will not answer in the hands, in which the fruit or nut bearing rods are attracted, will answer in those hands in which the others will not; so that all persons using suitable rods in a proper manner, have the virtue as it is called of the rod. A piece of the same willow placed under the arm, or the silk, worsted, or hair, bound round, or fixt to the top of it, will make it answer with those to whom the nut or fruit bearing rods are naturally suitable, and in whose hands without those additions it would not answer.

All rods, in all hands, answer to springs of water.

A piece of Gold held in the hand, and touching the rod, will not only hinder its being attracted by this Metal; but, on the contrary, the rod will be repelled towards the face. It is the same in regard to Copper as well as Gold, if the latter is held in the hand.

If Iron is so held, the rod will be repelled by that means. If any of the white Metals, viz. Silver, Lead, or Tin, be held in the hand, the rod will not be attracted, but repelled by all those Metals. It is the same with Limestone, Bone, and Coal. And, vice versa, if a person with whom the rod doth not naturally operate, holds a piece of Gold in his hand, the rod will then be attracted by Gold and Copper. The same holds good with all subjects of the rod.

On

driving adits, as the driving an adit through a Croſs-Goſſan is much eaſier than through the country.

In ſeeking for water by the rod, no notice is to be taken of thoſe ſingle attractions of the rod which are occaſioned by the commiſſures or crevices (called Caſes of Water by the Tinners) between the courſes or diſtinct runs of Killas; but a vein muſt be found, which anſwers to the rod as a Metal, and if this is ſunk unto a proper depth, a good quantity of water will be diſcovered.

It may not be amiſs to cloſe this little eſſay on the Virgula Divinatoria, with ſome few ſtriking inſtances of courſes, that have been cut by means of it in Cornwall.

A quantity of grain Tin having been found in the pond at Heligan, the ſeat of the reverend Mr. Henry Hawkins Tremayne; and it being a queſtion, whether this Tin might not come from ſome neighbouring Lode, it was diſcovered by the rod and ſunk upon; but it proved a barren Vein for Metal in any quantity. A ſhaft was ſunk at St. Germains, near the houſe of Francis Fox, to diſcover water; it drew the rod as Iron, and contained Mundick: another ſhaft was ſunk between Penzance and Newlyn, according to the direction of the rod; the faſt lay deep beneath the ſurface, but a Lode containing much Mundick was diſcovered. In a cloſe juſt by St. Auſtle, to ſatisfy the curioſity of ſome gentlemen, Mr. Cookworthy diſcovered by the rod the back of a Lode that had been wrought, but not turning to advantage the undertaking had been dropped, and the ground levelled. This Lode was traced juſt as the Miners informed the gentlemen it ran; and the Lode appearing by the rod at a certain place to be ſqueezed to nothing, the Miners declared this alſo to be true; for at this very ſpot where the Lode was thus ſqueezed, they loſt it. Being required to diſcover a Lode that had been tried in the cliff under St. Auſtle Down, he found it in the country by the rod, and traced it to the cliff. It was a large Goſſan-Lode; and as the attraction was found to ſtop, and after paſſing on a foot or two to begin again, he declared this was a cleft Lode, and had what the Miners call a Horſe in it, which the Miners preſent who had wrought in it declared to be true.

Hence it is very obvious, how uſeful the rod may be for diſcovery of Lodes, in the hands of an adept in that ſcience; but

but it is remarkable, that although it inclines to all Metals in the hands of unſkilful perſons, and to ſome more quick and lively than to others, yet it has been found to dip equally to a poor Lode, and to a rich one. I know that a grain of Metal attracts the Virgula, as ſtrongly as a pound; nor is this any diſadvantage in its uſe in Mining; for if it diſcovered only rich Mines, or the richer parts of a Mine, the great prizes in the Mining lottery would be ſoon drawn, and future adventurers would be diſcouraged from trying their fortune. But, indeed, we are ſo plentifully ſtored with Tin and Copper Lodes, that ſome accident every week diſcovers to us a freſh Vein; rich Mines having been ſeveral times diſcovered by children playing, and digging pits in imitation of ſhafts, whereby profits have ariſen to their parents and others; and theſe puerile diſcoveries have in ſundry places borne the name of Huel-Boys to this day.

Another way of diſcovering Lodes is by ſinking little pits through the looſe ground, down to the faſt or ſolid country, from ſix to twelve feet deep, and driving from one to another acroſs the direction of the Vein; ſo that they muſt neceſſarily meet with every Vein lying within the extent of theſe pits; for moſt of them come up as high as the ſuperficies of the firm rock, and ſometimes a ſmall matter above it. This way of ſeeking, the Tinners call Coſteening, from Cothas Stean; that is, fallen or dropt Tin.

Another and very ancient method of diſcovering Tin Lodes, is by what we call Shodeing; that is, tracing them home by looſe Stones, fragments, or Shodes (from the Teutonick Shutten to pour forth) which have been ſeparated, and carried off, perhaps, to a conſiderable diſtance from the Vein, and are found by chance in running waters, on the ſuperficies of the ground, or a little under.

When the Tinners meet with a looſe ſingle ſtone of Tin Ore, either in a valley, or in plowing, or hedging, though at a hundred fathoms diſtance from the Vein it came from; thoſe who are accuſtomed to this work, will not fail to find it out. They conſider, that a metallick Stone muſt originally have appertained to ſome Vein, from which it was ſevered and caſt at a diſtance by ſome violent means. The deluge, they ſuppoſe, moved moſt of the looſe earthy coat of the globe; and, in many places, waſhed it off from the upper, towards the lower grounds, with ſuch a force, that moſt of the backs of Lodes or Veins which

protruded

protruded themſelves above the faſt, were hurried downwards with the common maſs: whence the ſkill in this part of their buſineſs, lies much in directing their meaſures according to the ſituation of the ſurface.

Upon the top of moſt Tin Lodes, in the ſhelf or ſtratum under the looſe mould and rubbiſh of the earth, is that mineralized ſubſtance, which is called the Broil or Bryle of the Lode. Though it is a part of the Lode, yet it is different in ſituation and appearance from all other parts of it; foraſmuch as it is not confined between two walls, the ſtratum ſo near the ſurface being of a more lax tender texture, than in the ſolid rock a fathom or two under it. The Bryle, therefore, is very looſe, and in ſome places ſcarcely metallick, for want of depth, and of thoſe lateral chinks and cracks, which feed and nouriſh the Lode, at deeper levels, with Mineral principles educed from the ſtrata of the earth.

Such is the Bryle of a Lode; conſequently, when the waters of the deluge retired into their reſervoir, great part of the Bryles of Lodes were carried off by the force of the waters to various diſtances, according to the gravity of Shode Stones, and the declination of the plane upon which they were diſperſed. Tinners who deſcribe this diſtribution of Shode, to make it more eaſily underſtood, compare it to a bucket of water diſcharged upon the declivity of a hill; near the bucket, it will take up but a ſmall ſpace; but as it deſcends, will ſpread wider, in the manner of a truncated cone.

Hence it is manifeſt to reaſon and experience, that the more diſtant Shodes are from the Bryle of the Lode, the more diverged they are, and fewer in number; and, by parity of reaſoning, they are more in quantity near to the Bryle, and are collectively in leſs ſpace. Nevertheleſs, in ſome certain ſituations, they are in greater quantities in valleys, than on the tops or ſides of hills; but ſuch are ſmaller, and more eaſily carried down by water, and formed into ſtrata, which furniſh our ſtream works. In level ground, they are found ſcarcely removed from the Bryle; but on a declivity, they are always found diſperſed on the ſides of the hill, at a greater or leſs diſtance, in proportion to the length or declivity thereof, and their own ſpecifick weight: conſequently, the heavieſt Stones are neareſt to the Lode, and the lighter are protruded to a greater diſtance (even to five miles diſtance, as it is ſaid in Philos. Tranſactions no. 69) which are alſo nearer to the ſoil, by means of their levity and ſize; while the more groſs and weighty lie deeper interred as they are nearer the Lode. It is almoſt needleſs to obſerve, that as the texture, gravity, and black or brown colours of Tin Shodes, are different from all others; ſo they are thereby known and diſtinguiſhed, as well as by the ſmoothneſs of them a great diſtance from the Lode, and the acuteneſs of their angles when near to it; which entirely depends upon the trituration they have undergone, rolling over rough ſurfaces, by the force of water, and the attrition of other bodies paſſing over them.

Henckell and Roſler ſay, "That Mundick Shode is very "common; and that Wolfram, Granate, and Iron Corns, nay "Quickſilver, are found in Shode and Stream." "All of which," Henckell further ſays, "were waſhed and tore away from their "Veins, by the violence of the Noachian deluge."

Copper and Lead Shodes are very ſeldom met with; yet ſuch there are. Their Bryles being chiefly compoſed of tender unmetallick Goſſan, is not ſo well diſpoſed for bearing that force and attrition, as the more ſtoney matter of Tin Lodes are; and the former generally is not mineralized into Copper Ore at the Bryle.

It is a miſtake in thoſe who deny the exiſtence of any other Shode but Tin; ſo far from it, every hard ſtratum of the earth which is uppermoſt, will ſhew us numbers of their Shodes diſperſed from them at a diſtance, and reclined upon ſtrata of quite different natures, as hills and vallies are ſituated to help forward or retain thoſe rocky fragments. I think our diſtinct looſe Moorſtone, or Granite rocks, upon the ſides, and at the bottoms of our mountains, are the Shodes of their ſtrata underneath; and many large Shodes of Ireſtone are to be ſeen, though in leſs plenty, diſperſed upon Killas ſtrata at a diſtance from their parent rock: all of which are inconteſtible witneſſes of thoſe violent conquaſſations and convulſions of our country, at the time of the flood.

It is much to be lamented, that the ſcience of Shoding is greatly loſt in the preſent age. Among all our Miners, we have not fifty, who ſcientifically or experimentally underſtand any thing of the matter; and thoſe that are intelligent therein, are become old and feeble; whereby it is much to be feared, that

Stream, which is intermixed with ſtones, gravel, and clay, as it was torn from the adjacent hills.

When he ſinks down to the Tin ſtratum, he takes a ſhovel full of it, and waſhes off all the waſte; and from the Tin which is left behind upon the ſhovel, he judges whether that ground is worth the working or not. If it is proving work, he then goes down to the loweſt or deepeſt part of the valley, and digs an open trench, like the tail or low ſlovan of an adit, which he calls a Level, taking the utmoſt care to loſe no levels in bringing it home to the Stream. This level ſerves to drain and carry off all water and waſte from the workings, in proportion as he hath a weak or powerful current of water to run through it. Some places are very poor and not worth the expence for working; others again are very rich and thence called Beuheyle or Living Stream, as is moſt commonly the caſe if it is of a Grouan nature, which being more lax and ſandy, is more eaſily ſeparated from its native place or Lode, and therefore more abundant and rich in quality according to the known excellence of Grouan Tin.

In the latter caſe, the Streamer carries off what he calls the Overburden, viz. the looſe earth, rubble, or ſtone, which covers the Stream, ſo far and ſo large, as he can manage with conveniency to his employment. If in the progreſs of his working he is hindered, he teems (or lades) it out, with a ſcoop, or diſcharges it by a hand pump: but if thoſe ſimple methods are inſufficient, he erects a rag and chain pump ſo called; or if a rivulet of water is to be rented cheaply at graſs, he erects a water wheel with ballance bobs, and thereby keeps his workings clear from ſuperfluous water, by diſcharging it into his level: mean while his men are digging up the Stream Tin, and waſhing it at the ſame time, by caſting every ſhovel full of it, as it riſes, into a Tye, which is an inclined plane of boards for the water to run off, about four feet wide, four high, and nine feet long, in which, with ſhovels, they turn it over and over again under a caſcade of water that waſhes through it, and ſeparates the waſte from the Tin, till it becomes one half Tin.

Though there is little dexterity in this manœuvre, yet care is requiſite to throw off the Stent or rubble from the tye to itſelf, whilſt another picks out the Stones of Tin from the Garde or ſmaller pryany part of it. During this operation, the beſt of the Tin, by its superior gravity, collects in the head of the tye directly under the cascade; and by degrees becomes more full of waste, as it descends from that place to the end or tail of the tye, where it is not worth the saving. If there is a copious stream of water near at hand, they cast this refuse into it, by which it is carried so far as to make its exit into the sea, for which practice they certainly deserve our severest censure; at least, if the choaking of harbours and rivers, and the destruction of thousands of acres of improvable meadow land, are not more than an equivalent for the casual and temporary profits arising from Stream Tin.

I need not mention, that in the usual method of Streaming for Tin, the soil is either thrown into the bed of the rivers, or buried under the gravel and stones that form the interior strata; by which such land is rendered irreclaimable. That the Bounder, or working Tinner, should thus wantonly destroy what he had no interest in preserving, seems by no means extraordinary; but can we say the same for the lord of the soil?

Surely, it did not require any great degree of penetration, to have comprehended Streaming and Draining under one idea, and thus have made the improvement of the surface go hand in hand with the extraction of the Tin. The additional trouble of removing back the soil in heaps, and levelling the Stream ground to receive it, is so little that I know, by several instances, the Tinner will have but little reluctance in acceeding to; which the reader will readily apprehend when I assure him, the overburden upon the Stream is digged and rolled off at some distance, for only eightpence a cubick fathom; but at all events it is the interest of the proprietor to have it done, either by the Streamer or some other person. This method has been pursued in some parts of the county of Cornwall, and has been attended with the success so laudable an undertaking merits; as thereby those springs which lie too deep for the ordinary modes of draining, have been most effectually cured. I hope I shall not be accused of exaggeration when I assert, that the rental of this county, by following this obvious method of procedure, might have been increased in a proportion almost equal to the present value of the Stream Tin; and this too without lessening its produce, or injuring in the smallest degree the ducal revenue.

That this practice was not adopted by our ancestors, was owing to the small comparative value of land in those days, considering

considering either the ſtate of population or the uncertain and precarious tenures under their feudal lords. But when Britons have long ſince wreſted, from their petty monarchs, the property of the ſoil, together with the invaluable privilege of tranſmitting their improvements from father to ſon, that a cuſtom ſo injurious to the community, as well as to the individual, ſhould ſtill continue;

—— "pudet hæc opprobria nobis
"Et dici potuiſſe, et non potuiſſe refelli."

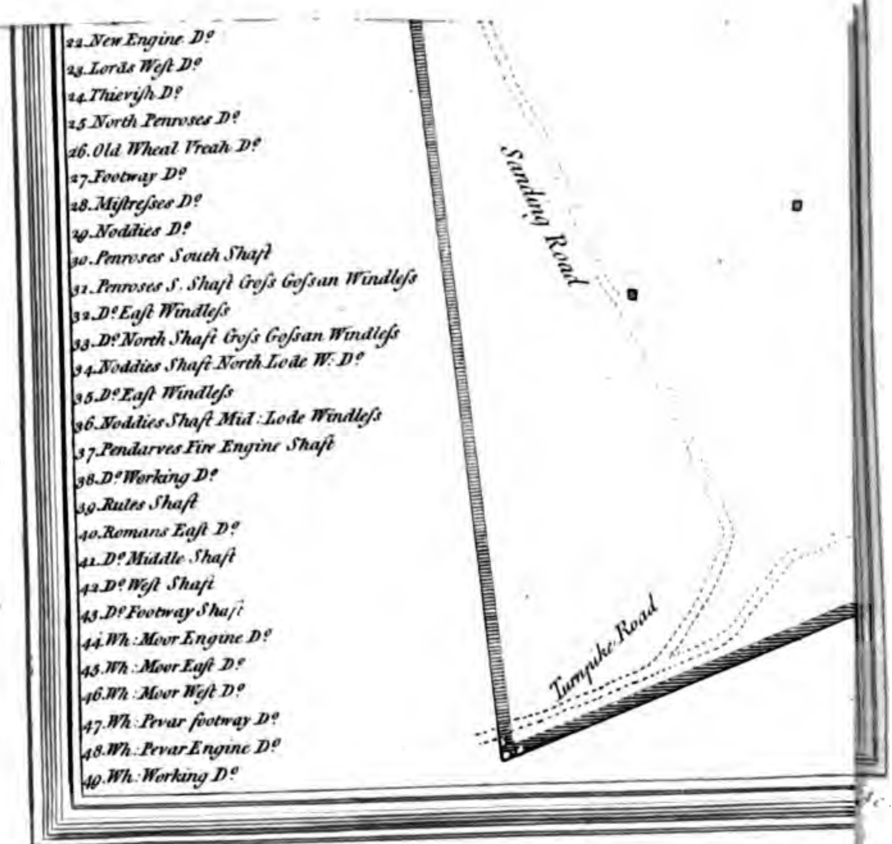
After the Tin is thus partly dreſſed in the raiſing of it, they carry it to graſs; and when a competent quantity is collected, they proceed to dreſs it for blowing. There are ſeveral ways of dreſſing this kind of Tin; but the general method is, to make what they call a Gounce, which is nothing more than a ſmall tie before deſcribed, and what we call in the Mining parts a Strêke, in which the ſmaller tin is waſhed over again as was done before in the tye, but with a leſs current of water, and a larger degree of care and caution, leſt the Tin be carried off with it. The richer part of the Tin, as before mentioned, lies neareſt the head of the gounce, which is carefully taken up, divided, or kept ſeparate, according to its goodneſs, and put into large vats or kieves; while the waſte that lies in the hinder part of the gounce, is dreſſed over again, till all the Tin is taken out, and the remaining waſte becomes abſolute refuſe. The Tin is then ſifted through wood or wire ſieves, whereby the greater particles are divided from the ſmaller; by this method, likewiſe, the waſte from its levity lies uppermoſt in the ſieve, which is carefully ſkimmed off, and laid aſide to work over again. The ſmalleſt Tin which paſſes through the wire ſieve, is put into another finely weaved horſe-hair ſieve, called a Dilluer, by which and the ſkill of the workman, it is made merchantable. Some of the nodules or lumps of Tin are blowed or ſmelted as they come out of the tie; but thoſe which are mixed with waſte, are put with the refuſe of the garde and poor Tin, which were in the tails of the tye and gounce, and being ſent to the ſtamping mill, are triturated and pulveriſed, ſo that all waſte may be cleared from the Tin by ſundry ablutions, the ſame as are performed in the dreſſing of Mine-Tin.

Beſides theſe Stream works, we have another ſort of them occaſioned by the refuſe and leavings from the ſtamping mills, &c. which are carried by the rivers down to the lower grounds; and

and after some years lying and collecting there, yield some money to the laborious dressers, whom they distinguish by the name Lappiors, I suppose from the Cornish word Lappior, which signifying a Dancer, is applied to them, from the boys and girls employed in this work, and moving up and down in the buddles, to separate the Tin from the refuse, with naked feet like to the ancient Dancers. I have been told, that about seventy years back, the low lands and sands under Perran Arwothall, which are covered almost every tide with the sea, have, on its going off, employed some hundreds of poor men, women, and children, incapable of earning their bread by any other means. To return:

Stream Tin being prepared and made ready for blowing with a charcoal fire, is carried to the blast furnace, which is called a Blowing-House; where, formerly, the Tinner might have his Tin blown, paying the owner of the house twenty shillings for every tide or twelve hours, for which the blower was obliged to deliver to the Tinner, at the ensuing coinage, one hundred gross weight of white Tin for every three feet, or one hundred and eighty pounds of Stream Tin so blown; which is equal to fourteen pounds of Metal for twenty of Mineral, clear of all expence. Now, that the blowing-houses are farmed, the Tin is usually blown and sold by sample, as the Mine-Tin is at the reverberatory furnaces.

The furnace itself for blowing the Tin, is called the Castle, on account of its strength, being of massive stones cramped together with Iron to endure the united force of fire and air. This fire is made with charcoal excited by two large bellows, which are worked by a water wheel, the same as at the Iron forges. They are about eight feet long, and two and a half wide at the broadest part. The fire place, or castle, is about six feet perpendicular, two feet wide in the top part each way, and about fourteen inches in the bottom, all made of moorstone and clay, well cemented and cramped together. The pipe or nose of each bellows is fixed ten inches high from the bottom of the castle, in a large piece of wrought Iron, called the Hearth-Eye. The Tin and charcoal are laid in the castle, stratum super stratum, in such quantities as are thought proper; so that from eight to twelve hundred weight of Tin, by the consumption of eighteen to twenty-four sixty gallon packs of charcoal, may be smelted in a tide or twelve hours time. Those bellows are not only useful for igniting the charcoal, but they throw in a steady and powerful



To the Rev.d Francis C

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powerful air into the castle; which, at the same time that it smelts the Tin, forces it out also through a hole at the bottom of the castle, about four inches high, and one inch and a half wide, into a moorstone trough six feet and a half high, and one foot wide, called the Float; whence it is laded into lesser troughs or moulds, each of which contains about three hundred of Metal, called Slabs, Blocks, or Pieces of Tin, in which size and form it is sold in every market in Europe; and on account of its superior quality is known by the name of Grain Tin, which brought a price formerly of seven shillings, that is further advanced, the last two or three years, to ten or twelve shillings ℔ hundred more than Mine Tin is sold for, because it is smelted from a pure Mineral by a charcoal fire; whereas Mine Tin is usually corrupted with some portion of Mundick, and other Minerals, and is always smelted with a bituminous fire, which communicates a harsh sulphureous injurious quality to the Metal.

CHAP. III.

Of Bounds and the Manner of taking a Set or Grant for Mining; of Sinking of Shafts, Driving of Adits, Digging and Raising of Ores, and Working the Mines, &c.

PREVIOUS to the working of a Tin Mine, a Grant or liberty must first be procured from the lord of the soil, if it is in Several and not bounded; but if the ground is in Wastrel and bounded, no liberty from the lord is necessary, but from the Bounder only. These Bounds are limited portions or pieces of land, enjoyed by the owners of them in respect of Tin only; and by virtue of an ancient prescription or liberty for encouragement to the Tinners. They are limited by holes cut in the turf, and the soil turned back upon the turf which is cut, in form of a mole hill, and directly facing another of the like kind; these are called Corners of the Bounds, containing sometimes an acre, sometimes more, and often less. By drawing straight lines from the Corners, the extent of these Bounds is determined; in like manner as in geometry, by drawing straight lines from three or four points, the extent of a triangular or quadrangular superficies is known.

By observing the legal forms, if the land is neither bounded nor inclosed, but a Wastrel or common, then may any one mark out Bounds there, and search for Tin; but, in compliance with the Stannary laws, whoever intends to cut a Tin Bounds must first give three months notice of his intention in the Stannary court, and to the lord, for him to shew cause why it shall not be done. By this procedure, the lord is advertised of a certain loss to himself, whence he presents an instrument, praying for liberty and enrolment of such Bounds within that Stannary, to his own behoof and benefit; whereby it is pretty clear, that new Bounds are at this day very seldom cut, to which the late gentlemen Stannators no doubt had an eye; because it is no uncommon thing for Bounders who have no title to any part of an estate above-ground, to grant sets for Tin without the least exception in favour of the Lord whose estate on the green side is oftentimes damaged by the destruction of the soil and the levelling of his fences, and so forth. The damage, however, is sometimes little to the lord of the soil, who has a fifteenth part of all that rises, which is some compensation for his loss.

It may be very difficult to ascertain the precise date when Bounds first commenced; but by consulting some manuscripts which were lent me by Francis Gregor, Esq; of Trewarthenick, whose father had been an able and upright vice-warden of our Stannaries, I observe that the Tinners wrought for their Tin by custom, until the 33d of Edward the first, which was sixty-four years after the Jews were banished, when they procured their charter, which was obtained at the sollicitation of the lords of Trethewy, Boswithgy, Treverbyn, Prideaux, Trenans, Austell, Tremedry, Tregarrick, and Milliack, who obliged their lands to pay assent, and do service to the law courts erected by the charter. I elsewhere find by some manuscript papers of John Cooke, Esq; one of the Stannators for Blackmore, 11th of Charles the first, "That by occasion of certain disputes, "and the Tynners having greate proffitts by their Tynn wrought "from time to time by custom, untill the 33d year of king "Edward the first, A. D. 1305; it was then thought good for "the Tynners to procure by charter from the prince, freely to "grante unto them libertye to digg and search for Tynn in any "place where Tynn mighte be found; and a court to deter-"mine all matters and causes between Tynnors." Accordingly I find this liberty expressly granted in the said charter, which says, "We have granted also to the Tynners, that they may "digge Tynn and turf for the melting of the Tynn, every-"where

"where in our lands, moores, and wastes; and of all other "persons whatsoever, in the county aforesaid." Mr. Beare also, in his Bayliff of Blackmore a manuscript of ancient note, in his discourse upon what the Tynners did before the charter was granted, says, "That they always used to worke, and search "for Tynn in wasterall grounds, and also in the prince's "Severall, where any Tynne mighte be gotten; having likewise "libertye to digge, mine, search, make Shafts, pitch Bounds; "and for Tynne to worke in places of their most advantages: "excepting only sanctuary grounde, church yards, mills, back "houses, and gardens; paying only to the prince or lord of "the soyle, the fifteenth part to and for the toll of their "Tynn."

The sum of all the intelligence I can procure, inclines me to judge, that all Tin was at first the possessionary right of him who had the government of the county, and from whom the liberty was granted, (or from the king) immediately to the searcher. (Plow. Com. Pearce's Stannary Laws; Sir John Doddridge.)

Without determining when a custom of that kind commenced, it is very natural to suppose, that those grants were limited and circumscribed within certain Bounds, beyond which, as at this day, the searchers dared not to pass. The acquisition of this valuable property, could not admit of its being in common; but under certain limits, and prescriptive forms, it must have been kept separate and divided between the sundry proprietors; in order that each person might know and preserve his own property. Whatever modes of partition the moderns might have thought of, there yet seems none more simple and decisive than those here described, which have existed from their first adoption to the present hour. Notwithstanding this, by the negligence of some owners of Bounds, the knavery of others, and the glorious uncertainty and chicane of the law, no Stannary affairs are so fertile of wrangles and disputes as those which relate to Tin Bounds.

The first institution of those customary tenures, for the encouragement of searching for Tin, was laudable and wise; but the late increase of Tin and discovery of Lodes, together with the present improvements in Mining, very much diminish the necessity of this kind of encouragement. On the contrary, from very good reaſons I can aſſert, it would be well for this country in general, if Tin Bounds were totally obliterated.

To preſerve the right of a Bounds, it ought to be renewed once every year, which is performed in different Bounds on different ſaints days, as St. John, St. Peter, St. Paul, &c. by the ſervant called the Tollur, the Renewer, or the Bounder, who cuts out a turf from each hole or corner, which he places upon the top of the little bank formed by the turfs already laid there, and declares the renewal to be on the behalf of ſuch perſon or perſons, the Bounds owners; from whence he generally goes to ſome houſe of entertainment, and takes a dinner, and other refreſhment, in order to celebrate and commemorate that annual renewing day.

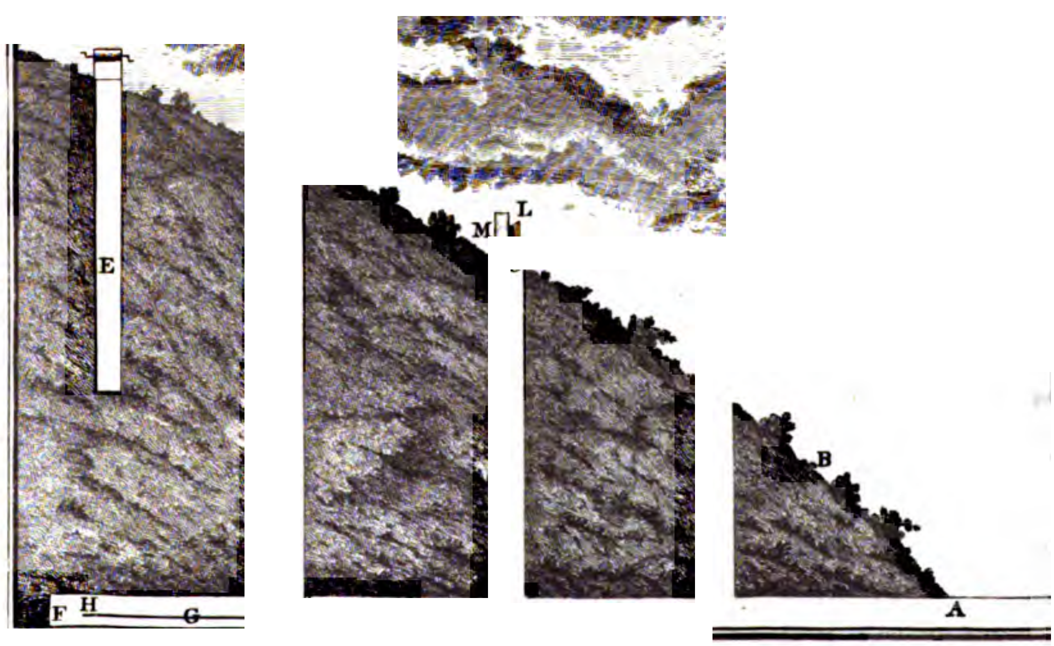
In Several, no man can ſearch for Tin without leave firſt obtained from the lord of the ſoil, who, when a Mine is found, may work it himſelf, or aſſociate partners, or ſet it out at a farm certain, or leave it unwrought at his pleaſure. In Waſtrel, it is lawful for the bounder, or any other perſon having liberty from him, to dig and ſearch for Tin, provided that he acknowledges the lord's right, by ſharing out unto him a fifteenth part of the whole. Then it is lawful for the Bounder to take out one-twelfth, or in ſome places by peculiar cuſtom one-tenth of the remainder. Tinners may drive an Adit through others Bounds without their liberty, only as a paſſage for their water; but if they break Tin or diſcover a Lode in their drift or ſinking of Shafts, they have no benefit of the ſaid Tin or Lode, but ſhall leave it wholly to the owners of the Bounds within which it is.

The uſual grant for Tin where it is not bounded, is the ſame as for Copper; and the acknowledgment, Diſh, or Dues paid to the lord, is commonly one-ſixth, ſeventh, eighth, ninth, even to one-twelfth, or leſs under ſome peculiar circumſtanccs; only that the dues for Copper are payable in money, and for Tin in the Stone or Mineral Ore, and ſometimes in white Tin or Metal. This grant by leaſe, is called a Set for Tin or Copper, and runs for one and twenty years certain. But a Set of a Bounds for Tin, though verbal, is perpetual, and never ends while it is wrought according to the laws and cuſtoms of the Stannaries; that is, if the Tinner has been in quiet poſſeſſion for the ſpace of one year and a day, he may ſtill keep his holding at five ſhillings expence annually, laid out upon the premiſes. This

incommodious; then it is proper to put down another Shaft as before described, or more to the north, because it will be more convenient, the longer it continues downright. Mean while, they are mindful to sink their first Shaft in order that they may work away the Lode from thence in Stopes, and have a little Sump or pit in that place as a bason for receiving the water of the Lode, whence they discharge it to grass by the easiest method they can devise: for most Lodes have streams of water running through them; and when they are found dry, it seems to be owing to the waters having been forced to change their course, either because the Lode has stopped up the old passages, or because some new or more easy ones are made, whereby the Lode and strata adjacent to it are bleeded as we term it. However, they are often hindered from going down deep enough to find any great quantity of Ore, by the burden of water that most Veins abound with; therefore, if the Mine is not encouraging, they give over any further pursuit; but if it seems likely to prove well, and the Lode lies in an ascending ground, they quit the Vein for the present, and go down to the most convenient place in the valley, and from thence they bring a Trench, Drain, or Conduit, which they call an Adit, Tye, or Level; and so they work and drive this passage through the hill in a right line to the Lode, with very little loss of the level they began from.

Where the Adit is intended only for the sake of unwatering one particular Vein, it is frequently adviseable to bring it home on the course of it, if the situation of the ground will admit, because this is a continual trial of it at that depth: yet, if there are many Lodes not far asunder, an Adit brought home athwart them may sometimes be preferable, if it can be conveniently complied with; for the situation of the ground must be well considered, to judge how to drive home the most short, deep, speedy, and cheap Adit, with the most probable success.

If the hill takes its course east and west a considerable length, and the discovery of the Vein is very far from a valley at either end of the hill, there may be no choice in the matter; for the shortest and cheapest Adit will of course be driven from the north or south, unless moorstone or irestone strata intervene. It then behoves the adventurers to seek for a Cross-Gossan, where it lies convenient in distance from the discovery, to bring home the Adit in; and provided the Gossan does not exceed three feet in width, it is reckoned very favourable, because the


E
F
H
G
M
L
B
A

Saller, the boards being hollow underneath, air is conveyed to the workmen.

To make these matters clear with regard to driving and Sallering an Adit, let us suppose A to be the lost slovan or tail of the Adit, the level from which the Adit was first driven, all open to grass, till it took into the side of the hill B. A little further on they put down an Adit Shaft for air, or conveyance of the deads from the Adit. The next Shaft C, was sunk for the same purposes; and so was D, which is represented as the present working Shaft, for the other Shaft E is not sunk down upon the Adit end F. For want of the Shaft E being holed upon the end F, the air is very close and suffocating; nay, the Adit end must be deserted for want of air. To remedy this, they go behind the shaft D, and put in a Saller, or close stage of boards G, about one foot high from the bottom of the Adit, which is continued within five or six feet to the end at H, where it is open and discharges the air back through the Adit and up the Shaft I I, because that is totally stopped by an exceeding close door at K. There is another way of forcing down air by an air pipe, as at the Shaft C; the top of which L, can be turned towards the wind when it blows from any quarter, and receives the air which is forced down through the funnel M into the Adit at N, whence it circulates back again through the former workings.

This air pipe is seldom used in Adits, because the Saller is more cheap and easy, the difference of expence in the air pipe being considerable where an Adit Shaft is thirty or forty fathoms deep; besides, the Saller under the workmen's feet is less incommodious, than the funnel over their heads: nevertheless, this air pipe is of indispensable use in the sinking a Shaft that is void of circulation of good air, and it is seldom that a Shaft of forty fathoms depth can be sunk without an air pipe all the way down from grass, provided the Shaft has no communication, by drift or Gunnies, with some other parts of the workings. It must be noted, that great care is requisite to stop close every crevice of the air pipe, or the Saller, with clay or pitch and oakum, so that not a breath of air shall escape. The Saller, indeed, may be covered close with turf and earth laid all round and upon it; whereby no air can have vent but at its proper place H. By duly attending to this circumstance, an Adit may be driven beyond one hundred and fifty fathoms, before a Shaft need be sunk down upon it. This is an affair of no mean consequence,

consequence, where a Shaft must be sunk very deep in exceeding hard ground.

Sir Robert Moray, in the Philosophical Transactions No. 5, has communicated a method practised at Liege for driving of Adits without air Shafts, by erecting a chimney thirty feet high, at the tail or loft slovan of the Adit, from whence an air pipe is continued through the Adit; whereby all foul air at that place is invited or drawn, by the fire, from the working part or end of the Adit unto the chimney, where it enters under the grate filled with live coal and suspended in the middle of the chimney. This may serve, where the air is rendered noxious by sulphureous or vitriolick effluvia, to carry it off by the funnel into the chimney; but in our Adits we have no vapourous fumes to discharge. With us it is an absolute want of air, or circulation thereof; so that our relief is only acquired by pouring in a fresh current of air, and continuing the circulation as freely and uniformly as possible.

The numerous little eminencies that compose the face of our country, where the Mines are situate, afford us great advantages for Adits to unwater the Veins contained in them. Though we seldom see an Adit half a mile in length, there are two or three of three times that length, and those are the longest I know of. At Friberg in Saxony, they have very extraordinary works of this kind, particularly that called the Prince's Level, one of the greatest works in those parts, considering the time, labour, and expence necessary to work a passage under-ground, for about five English miles in length.

The labour and expence of driving this level, must have been great and tedious, where it happened in such exceeding hard ground as we sometimes meet with here: for although I have known an Adit end driven several fathoms at four shillings a fathom in Pot Grouan, that is, soft grouan; yet I have paid twelve guineas for the same Adit, that we have driven many score fathoms for less than one; so various and uncertain are the strata of the earth in these parts. The greatest expence for the ground discovered, that I ever heard of in driving an Adit, was in the old Pool, two miles off, where Mr. Basset paid five and thirty pounds ℔ fathom for the driving of several fathoms, through an Irestone stratum; which great price answered so badly for the contractors, that they were very much injured by the undertaking. The most desirable ground to drive an Adit in, in, where it cannot be brought home upon the Lode itſelf, or a croſs-courſe, is a tender feaſible Killas of eighteen ſhillings ℔ fathom. This ground needs no timber to ſupport it, and can be ſpeedily ſpent or worked at the rate of eight or ten fathoms monthly.

If an Adit is ſet by the fathom, and the ground proves hard, the workmen are often regardleſs of driving in a direct ſtraight line, and are apt to drive irregularly for the advantage of working in the faireſt ground; but this makes a reckoning of more fathoms to the adventurers diſadvantage, than they ought in juſtice to be accountable for; therefore it is the moſt prudent method, when an Adit is ſet by the fathom, to agree, that the meaſurement ſhall be on the graſs or ſurface, becauſe then if the workmen drive out of the way it will be their own loſs.

In bringing home theſe levels, the natives of Cornwall never conſider the expence ſo much as the time it may be performed in: indeed, it is an axiom in Mining, that the quicker an Adit is driven, the leſs muſt be the expence. Some levels have taken thirty years to complete them; and I have been concerned in one that took ſeventeen years to bring it home to the Mine. Yet notwithſtanding all diſadvantages, ſundry levels have been carried acroſs as meer ſeeking adventures, for the ſake of diſcovery, without being bound for any particular Mine; and ſome of them, by patience and perſeverance, have amply rewarded the enterprize.

I muſt allow that ſuch adventures are very laudable; for if a level forms an horizontal acute angle with the perpendicular ſection of the ſummit of a hill, at the charge of three thouſand pounds in fifteen years driving, though without the ſucceſs deſired, it is likely to prove an uſeful undertaking for poſterity, who may reap the advantage of it, when they want levels to unwater veins that may be diſcovered in other parts of the hill. The expence of an adit is ſlow and ſmall; therefore it is eaſily borne. Two or three hundred pounds a year in driving an Adit, is ſcarcely felt by eight or ten perſons, than whom ſeldom fewer are concerned; and this too upon the chance of finding a vein, or veins, that may throw up an amazing profit preſently after diſcovery, by an advantage in the very means of diſcovery itſelf.

An Adit being driven home to the Mine, the water ſeldom fails of draining and falling into it; ſo that the Lode is unwatered as deep as the level of the Adit, to which depth, or yet a greater, the men are at liberty to ſink and drive on the Lode if they think proper.

With all the ſkill and adroitneſs of our Miners, they cannot go any conſiderable depth below the Adit, before they muſt have recourſe to ſome contrivance, for clearing the water from their workings. The hand pump, and the force pump, will do well for ſmall depths, and are neceſſary in the firſt ſinkings into the Lode, before the Stopes can proceed. Next to theſe, the water is drawn to Adit by ſmall water barrels; but if the water exceeds a certain number of barrels, in a core of ſix or eight hours, they give over drawing by hand, and erect a Whym, which is a kind of horſe engine to draw water or work, and ſometimes both, eſpecially in the infancy of a Mine. A common Whym which ſerves both purpoſes, conſiſts of a perpendicular axis, whereon a large hollow cylinder of timber turns, called the Cage, round which the rope winds horizontally, being directed down the Mine by two pullies fixed in what are termed Puppet Heads over the mouth of the Shaft: this axis has a tranſverſe beam, called the Arm infixed; at the end of which are placed two horſes that go round upon a platform named the Whym-round, and draw more or leſs according to the number of their circumvolutions in any given time, the largeneſs of the barrels, and the depth the Whym is to draw. For drawing of water, this engine can only work in a perpendicular Shaft; but for winding of work or deads, it can be uſed to draw upon the underlie of the Lode.

Another water engine is the Rag and Chain, which conſiſts of an iron chain with knobs of cloth ſtiffened and fenced with leather, ſeldom more than nine feet aſunder: the chain is turned round by a wheel of two or three feet diameter, furniſhed with iron ſpikes, to incloſe and keep ſteady the chain, ſo that it may riſe through a wooden pump of three, four, or five inches bore, and from twelve to twenty-two feet long, and by means of the leather knobs bring up with it a ſtream of water anſwerable to the diameter of the pump, and in quantity according to the circumvolutions of the wheel in any given time. Several of theſe pumps may be placed parallel upon different Stulls, Sallers, or Stages of the Mine, and are uſually worked by hand like thoſe in our navy. The men work at it naked excepting their loose trowsers, and suffer much in their health and strength from the violence of the labour, which is so great that I have been witness to the loss of many lives by it.

A rag and chain pump of four inches diameter, requires five or six fresh men, every six hours, to draw twenty feet deep; and to keep it constantly going, twenty or twenty-four men must be employed monthly, at forty or fifty shillings each man. The monthly charge of one of these engines cannot be less than fifty or sixty pounds; and they are now pretty generally laid aside on account of the great expence, and the destruction of the men. Nevertheless the motion of the rag and chain, when it is constant, is so quick, that it will discharge a quantity of water, even exceeding that of a wheel and bob engine, whose pump is 10 inches bore; and it may be usefully applied to draw water from sundry parts, such as dippas or little pits of a Mine, which have no communication with other aqueducts to the grand machinery for delivering of the water to Adit.

Where the rag and chain pumps are unequal to the work, and too chargeable for the Mine to repay, they may have recourse to the whym again; and instead of drawing with sixty gallon barrels as at first, they may put in larger ones to the amount of 120 gallons in each barrel drawn by the additional help of two horses more. This draught must be within twenty fathoms, and not less than two barrels a minute, to be worth the charge.

The water wheel with bobs, is yet a more effectual engine; whose power is answerable to the diameter of the wheel and the sweep of the cranks fixed in the extremities of the axis. Over them two large bobs are hung upon brass center gudgeons supported by a strong frame of timber, and rise and fall according to the diameter of the sweep of the cranks, or of the circle they describe. To each crank is fixed a straight half split of balk timber, that communicates with each bob above: at the other hand or nose of the bob over the Shaft, a large iron chain is pendent, fastened to a perpendicular rod of timber that works a piston in an iron or brass hollow cylinder, called the Working Piece: the quantity of water exhausted, will be in proportion to the bore of the working piece, and the number of times which the embolus works up and down in a given space. The water engine wheel at Cooks Kitchen Mine, is forty-eight feet diameter, and works her tiers of pumps of nine inches bore, which

which being divided into four lifts, draws eighty fathoms under the Adit. If the ſtream of water were ſufficient to fill the buckets of the wheel, ſhe would draw forty fathoms deeper with the ſame bore; and I have been well informed, that the power of a forty-eight feet wheel, is equal to the diameter of a forty-ſeven inch fire engine houſe cylinder: whence this kind of engine is the moſt eligible, where graſs water is plenty, and to be had for a ſmall rent.

The number of ſtamping mills adjacent to the Mines, and the value of water for the various ablutions of Tin and Copper Ores, render every ſmall rivulet of ſome conſiderable conſequence to thoſe through whoſe lands the water happens to flow. Many of our country gentlemen have made great rents of their water courſes, when they have been diverted from their griſt mill tenants; and ſome of them, without any recompence made to the leſſees, have received fifty pounds a month, ſeveral years, for a ſmall mill ſtream of water to drive one of thoſe engine wheels upon Mines in their own lands.

Happy would it be for the Mining intereſt, if our ſuperficial ſtreams of water were not ſo ſmall and ſcanty; but the ſituation of our Mines, which is generally in hilly grounds, and the ſhort current of our ſprings from their ſource to the ſea, prevent ſuch an accumulation of water, as might be applied to the purpoſe of draining the Mines; and of courſe the value of water is the more enhanced. There are very few ſtreams, which are ſufficient to anſwer the purpoſe in ſummer, as well as in winter, ſo that many engines cannot be worked from May to October; which is a great loſs at that ſeaſon of the year, when men can work longer at graſs, and with more vigour, than they can in ſhort days and cold weather. Yet the innumerable Adits driven into the earth, afford tolerable ſupplies of water to thoſe ſtreams, and are of ſome importance to the unwatering of the Mines. By the ſuperior addreſs of our Miners, the rivulets are often extended many miles to drive an engine; and are then returned as far back again as poſſible, to ſerve other Mines and ſtamping mills; beſides, the moiſture of our air and ſituation, which is directly expoſed to the great weſtern ocean, as well as to the Britiſh and Briſtol Channels, cauſes abundance of rain, and contributes not a little to ſwell our ſmall rivers after the autumnal equinox.

But where the ſituation of a Mine will not admit of a water engine, or where the ſtream is inſufficient, the laſt reſource is that moſt uſeful, powerful, and noble machine, the fire engine, of which we have ſeveral that are perhaps the largeſt in the kingdom. It is the moſt admirable curious and compounded machine amongſt all that owe their invention to the diſcoveries of modern philoſophy, and affords the greateſt advantages to mankind. The marquis of Worceſter, in his century of inventions publiſhed in the year 1663, is probably the firſt that propoſed raiſing any great quantities of water by the force of fire converting water into ſteam; but captain Savery was the firſt who erected an engine for this purpoſe in the form we have ſince had them, and which has been lately improved by Mr. Blakey, though not to a degree of power ſufficient to unwater a deep Mine.

Mr. Newcomen, and Mr. J. Cawley, contrived another way to raiſe water by fire, where the ſteam to raiſe the water from the greateſt depths of Mines is not required to be greater than the preſſure of the atmoſphere; and this is the ſtructure of the preſent fire engine, which is now of about ſeventy years ſtanding.

Let us ſuppoſe a pump, or tier of pumps as we ſay, to be twenty-five fathoms deep, whoſe cylindric diameter of its full column of water is ſeven inches and a quarter, and of the weight of 3,000 ℔. Now if the rod of this pump were hung by a chain to the noſe of the lever or bob, h h, as at H; and at the other end, another power were applied, as at L, with a ſuperior force; the pump might be worked, and the water raiſed by that power. It appears, this power cannot be ſupplied by the ſtrength of man, or beaſt; for it will require one hundred men to pull down the bob, each pulling with the force of 30 ℔, and one hundred men to relieve them when weary. But as the pump in a Mine muſt not ſtand ſtill, there ſhould, for ſuch hard labour, be a freſh corps of one hundred men every four hours at leaſt, which would amount to ſix hundred men every twenty-four hours. If we allow horſes, and one horſe equal to five men, there muſt be twenty horſes working at a time, and twenty more to relieve them every four hours, where the draft muſt be ſo conſtant and exceſſive; which will amount to one hundred and twenty horſes every twenty-four hours; and ſo great a number, though leſs expenſive than men, will be found too great for moſt Mines, if it were poſſible to apply them to that uſe. I produce this example, to ſhew the prodigious force that is required to draw water in the ſmall epitome of a Mine; for the diameter of the pump given, and the depth of twenty-five fathoms, bear the leaſt analogy to the depth of our Corniſh Mines, whoſe fire engine houſe cylinders are generally from fifty-four to ſeventy inches diameter. Now allowing 8 ℔ to each ſquare inch, clear of friction, in the power of a fire engine houſe cylinder of ſeventy inches diameter; the number of pounds avoirdupoiſe within its extent of power to lift up or pull down, are equal to 30,784 ℔. The human power equal to this will require the ſtrength of 1,026 men every four hours, or 6,156 men the day and night; or 1,230 horſes. A ſixty inch cylinder, alſo, which will lift 22,616 ℔, is equal to 4,518 men, or 900 horſes, every twenty-four hours. Some other power therefore muſt be applied; which may be effected as follows. B is a large boiler, whoſe water, by the fire under it, is converted into an elaſtick ſteam. (See plate III) The great cylinder C C is fixed upon it, and communicates with it by the pipe D d; on the lower orifice of which, within the boiler, moves a broad plate, by means of the ſteam cock, or regulator E 10, ſtopping or opening the paſſage to prevent or permit the ſteam to paſs into the cylinder, as occaſion requires. The diameter of the pipe D is about four inches.

The ſteam in the boiler ought always to be a little ſtronger than the air, that, when let into the cylinder, it may be a little more than a ballance to the external air, which keeps down the piſton at the bottom d n. The piſton being by this means at liberty, the pump rod will, by its great weight, deſcend at the oppoſite end to make a ſtroke, which is more than double the weight of the piſton, &c. at the other end. The end of the lever at the pump, therefore, will always preponderate and deſcend, when the piſton is at liberty. The handle of the ſteam cock E 10, being turned towards n, opens a pipe D to let in the ſteam; and being turned towards O, it ſhuts it out, that no more can enter. The piſton is now raiſed towards the top of the cylinder at C, and the cylinder is full of ſteam. The lever O 1 muſt then be lifted up, to turn, by its teeth, the injecting cock at N, which permits the water, brought from the ciſtern g by the pipe g M N, to enter the bottom of the cylinder at n, where it flies up in the form of a fountain, and ſtriking againſt the bottom of the piſton, the drops, being driven all over the cylinder, will, by their coldneſs, condenſe the ſteam into water again, and precipitate it to the bottom of the cylinder.

Mr.

Mr. Beighton made an experiment to determine the rarity of ſteam, and found the content of a certain cylinder of ſteam was 113 gallons; and ſince there were 16 ſtrokes in a minute, therefore $113 \times 16 = 1808$ gallons of ſteam ℔ minute. He alſo obſerved, that the boiler proportioned to that cylinder, required to be ſupplied with water at the rate of five pints ℔ minute: and ſince 282 cubick inches make a gallon, $35\frac{1}{4}$ make a pint, and $5 \times 35\frac{1}{4} = 176\frac{1}{4}$ in five pints: alſo the cubick inches of ſteam are $1808 \times 282 = 509856$; if then we ſay, as $176\frac{1}{4} : 509855 :: 1 : 2893$; or one cubick inch of water is expanded into 2893 inches of ſteam; conſequently the ſteam in the cylinder is reduced to $\frac{1}{2893}$ part, when turned to water by the jet of cold water; and therefore a ſufficient vacuum is made in the cylinder, for the piſton to deſcend, unballanced, by the preſſure of the atmoſphere. The piſton being forced down, raiſes the other end of the lever or bob, and conſequently the box of the pump under-ground, which brings up and diſcharges the water at adit, the ſame as at p. Now this whole operation of opening and ſhutting the ſteam regulator and injection cock, will take up but little more than three ſeconds; and will, therefore, eaſily produce 16 ſtrokes in a minute.

That the ciſtern g may always be ſupplied with water, there is an arch fixed near the arch or noſe of the bob H, from whence another pump rod k, with its box and valve, draws water from the level of the adit in the ſame engine ſhaft, and forces it up the pipe m m m into the ciſtern g, which, therefore, can never want water.

That the leathers of the piſton C may be always ſupple and ſwelled out, ſo as to be conſtantly air tight, a ſmall ſtream of water is ſupplied from the injecting pipe M by the arm Z. On the top of the cylinder is a larger part or cup L, to hold the water that lies on the piſton, leſt it ſhould overflow when the piſton is got to its greateſt height, as at W; at which time, if the cup be too full, the water will run down the pipe V to the waſte well at Y.

The water in the boiler, which waſtes away in ſteam, is ſupplied by a pipe I i about three feet long, going into the boiler a foot below the ſurface of the water. On the top of this pipe is a funnel I, ſupplied by the pipe W with water from the cup of the cylinder, which has the advantage of being always warm, and therefore not apt to check the boiling of the water. That the

the boiler may not have the ſurface of the water too low, which would endanger burſting; or too high, which would not leave room enough for ſteam; there are two gage pipes at G, one going a little below the ſurface of the water when at a proper height, and the other ſtanding a little above it. When every thing is right, the ſtop cock of the ſhort pipe being open, gives only ſteam, and that of the long one water; but, if otherwiſe, both cocks will give ſteam when the ſurface of the water is too low, and both give water when it is too high; and hence the cock which feeds the boiler at I, may be opened to ſuch a degree, as always to keep the ſurface of water to its due height.

The cold water, conſtantly injected into the cylinder to condenſe the ſteam, is carried off by the eduction pipe d T Y, leading from the bottom of the cylinder to the waſte well Y, where going a little under water, it has its end turned up, with a valve Y, to keep the air from preſſing out into the pipe, but permitting the injected water coming the other way to be diſcharged, whereby the cylinder is kept empty.

Leſt the ſteam ſhould grow too ſtrong for the boiler, and burſt it, there is a valve fixed at h, with a perpendicular wire ſtanding up from the middle of it, to put weights of Lead upon, in order to examine the ſtrength of the ſteam puſhing againſt it from within. Thus the ſteam is known to be as ſtrong as the air, if it will raiſe up ſo much weight on the valve, as is at the rate of fifteen pounds to an inch ſquare, becauſe that is the weight of air, nearly, on every ſquare inch. When the ſteam becomes ſtronger than is required, it will lift up the valve, and go out: this valve is called the Puppet-Clack. The ſteam has always a variable ſtrength, yet never one-tenth ſtronger or weaker than common air; for it has been found, that the engine will work well when there is the weight of one pound on each ſquare inch of the valve: this ſhews, that the ſteam is then one-fifteenth part ſtronger than the common air. Now as the height of the feeding pipe, from the funnel F to the ſurface of the water G s, is not above three feet, and three feet and a half of water is one-tenth of the preſſure of the air; if the ſteam were one-tenth part ſtronger than air, it would puſh the water out at E; and ſince it does not, it cannot be ſtronger than air, even in this caſe, where, the regulator being ſhut, it is moſt of all confined. When the regulator is opened, the ſteam gives the piſton a puſh, which raiſes it up a little way; then filling a greater ſpace, it comes

comes to be of the ſame ſtrength with, and ſo a ballance to, the atmoſphere: thus the piſton, being at liberty, riſes to the top W. The ſteam, now expanded into the whole capacity of the cylinder, is weaker than the air; and would not ſupport the piſton, were it not for the greater weight at the other end of the lever, which keeps it up. The ſteam, each ſtroke, drives the injected water of the preceding ſtroke out of the eduction pipe d T Y; and would itſelf follow, and blow out at the valve Y, which is not loaded, if it were ſtronger than the air, which it never does. If it were exactly equal to the ſtrength of the air, it would juſt drive all the water out at Y; but could not follow itſelf, the preſſure being equal on each ſide the valve by ſuppoſition. If it be weaker than the air, it will not force all the water out of the pipe at d T Y; but the ſurface will ſtand, ſuppoſe at T, where the column of water T Y, added to the ſtrength of the ſteam, is equal to the preſſure of the air. When the ſteam is one-tenth weaker than the air, the height T Y = three feet and a half. Now, ſince the whole perpendicular diſtance from d to Y is but four feet, and the ſteam always ſufficient to expel the water; it is plain, it can never be more than one-tenth part weaker than the air, when weakeſt.

There is air in all the water injected; and though that air cannot be taken out or condenſed with the ſteam, yet will it precipitate through the ſteam to the bottom of the cylinder, as being much heavier: for ſteam is to water, as 1 to 2893, in its denſity; but the denſity of air is to that of water, as 1 to 864 nearly; therefore the rarity of ſteam is to that of air, as 2893 to 864: the air will, therefore, fall through the ſteam to the bottom, and from thence be driven out through a ſmall pipe opening into the cup at 4, on which is a valve. Now when the ſteam firſt ruſhes into the cylinder, and is a little ſtronger than the outward air, it will force the precipitated air to open the valve at 4, and make its eſcape; but the ſteam cannot follow, becauſe it is weaker than the outward air, as the piſton gives it room, by aſcending, to expand. This valve, from the noiſe it makes, is called the Snifting-Clack.

Among the great improvements of this engine, we may reckon that contrivance by which the engine itſelf is made to open and ſhut the regulator and injection cock, and that more nicely than any perſon attending could poſſibly do it. For this purpoſe, there is fixed to an arch 12, at a proper diſtance from the arch P, a chain, from which hangs a perpendicular piece or working beam Q Q, which comes down quite to the floor, and goes through it in a hole, which it exactly fits. This piece has a long slit in it, and several pin holes and pins, for the movement of small levers destined to the same office of opening and shutting the cocks, after the following manner: between two perpendicular pieces of wood, on each side, there is a square iron axis A B (plate III, fig. 2) which has upon it several iron pieces of the lever kind. The first is the piece C E D, called the Y, from its representing that letter, inverted by its two shanks E and D; on the upper part is a weight F to be raised higher or lower, and fixed, as occasion requires. This Y is fixed very fast upon the said iron axis A B.

From the axis hangs a sort of an iron stirrup I K L G, by its two hooks I G, having on the lower part two holes K L, through which passes a long iron pin L K, and keyed in the same. When this pin is put in, it is also passed through the two holes, in the ends E N, of the horizontal fork or spanner E Q N, joined at its end Q to the handle of the regulator V 10. From Q to O are several holes, by which the said handle may be fixed to that part of the end which is most convenient. Upon this axis A B, is fixed, at right angles to the Y, an handle or lever G 4, which goes on the outside of the piece Q 2, Q 2, and lies between the pins. Another handle is also fastened upon the same axis, viz. H 5, and placed at half a right angle to the former G 4; this passes through the slit of the piece Q 2, Q 2, lying on one of the pins. Hence we see, that when the working beam goes up, its pin in the slit lifts up the spanner H 5, which turns about the axis so fast as to throw the Y, with its weight F, from C to 6, in which direction it would continue to move, after it had passed the perpendicular, were it not prevented by a strap of leather fixed to it at œ, and made fast at the ends m and n in such a manner as to allow the Y to vibrate backwards and forwards about a quarter of a circle, at equal distances, on this side and that of the perpendicular.

In the representation we have given, the regulator appears open, its plate T Y being shewn on one side the pipe S, which joins the cylinder and boiler. The piston is now up, and also the working beam near its greatest height; the pin in the slit has so far raised the spanner H 5, that the weight F on the head of the Y is brought so far from n, as to be past the perpendicular, and ready to fall over towards m, and, when it does so, it will by its shank E, with a smart blow, strike the iron pin K L, and

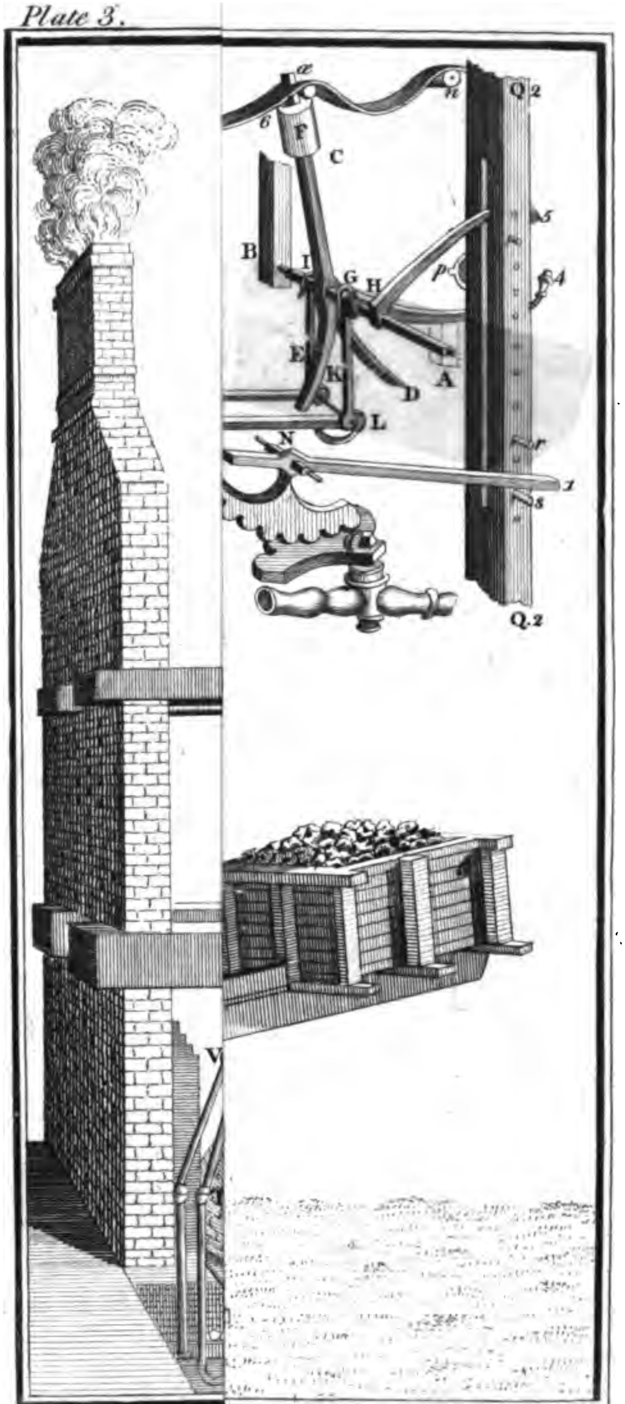
and drawing the fork horizontally towards the beam Q, will draw the end 10 of the regulator towards 6, and ſhut it, by ſlipping the plate Y under the holes of the throat pipe S. Immediately after the regulator is ſhut, the beam riſing a little higher, with its pin s on the outſide upon the lower part, lifts up the end k 1 of the handle of the injection cock, and opens it by the turning of the two parts with teeth. The jet immediately making a vacuum, the beam again deſcends, and the pin r depreſſing the handle k 1, ſhuts the injection cock; and the beam continuing to deſcend, the pin p bears down the handle G 4, and throwing back the Y, its ſhank D throws forward the fork N Q, and again opens the regulator to admit freſh ſteam. All the parts now begin afreſh to operate; and thus is the engine moſt wonderfully contrived to work itſelf. After the engine had been made, as above deſcribed, for many years, it received another improvement of very great advantage; and that was, inſtead of feeding the boiler with warm water from the top of the cylinder by the pipe W (fig. 1) above, and F f below, it was ſupplied with the ſcalding hot water which comes out of the eduction pipe d T Y, which now, inſtead of going to the waſte well at Y, was turned into the boiler on the top part; and as the eduction pipe before went out at the ſide of the cylinder, it was now inſerted in the bottom of the ſame: and though the preſſure of ſteam in the boiler, be ſomewhat greater in the cylinder, yet the weight of water in the eduction pipe being added to the force of ſteam in the cylinder, will carry the water down continually, by overcoming the reſiſtance in the boiler. (Martin.)

To this deſcription of the fire engine, I ſhall add a moſt curious and uſeful table of the calculation of the power of fire engines for the various diameters of the houſe cylinder, and bore of the pump or pit-barrel, that are capable of raiſing water, at any depth between 2 and 876 fathoms. It was compoſed by Mr. John Nancarrow, jun. and is founded on this principle, that the ale-gallon of 282 cubick inches of water, weighs ten pounds three ounces, avoirdupois; and a ſuperficial ſquare inch is preſſed with the weight of fourteen pounds thirteen ounces of air, when of a mean gravity. But allowing for ſeveral frictions, and to give a conſiderable velocity to the engine, it is found by experience, that no more than eight pounds of preſſure muſt be allowed to an inch ſquare on the piſton in the cylinder, that it may make about ſixteen ſtrokes in a minute, about ſix feet each ſtroke. The uſe of this table is eaſy: if I want to know the power

power of a 60 inch. houſe cylinder, to work a pit-barrel or working piece of 12 inches diameter; I look in the firſt column for the diameter of the houſe cylinder, till I find the No. 60: I then go on in that line to my right, till I come under 12 of the uppermoſt line, which is the diameter of the pit-barrel or working piece, and there find 79, the number of fathoms an engine of that power will draw; that is, a houſe cylinder of 60 inches diameter, will draw with a 12 inch. box, 79 fathoms.

The Mine being ſupplied with a power for the diſcharge of the water, and the adventurers reſolving to prove it at a good depth, they ſink down the engine Shaft continually, or keep it lower than their workings upon the courſe of the Lode, with which it has always a deep communication, that the water may readily flow to the engine pumps, and be drawn to Adit. The bottom of the engine Shaft, while it is deeper than the workings upon the Lode, is properly the Sumph or Sink of the Mine; and this ſhould ever be the caſe, for the Mine to be in regular courſe of working: but when an engine is worked to the full extent of its power, it is common to ſink a Sumph in the Lode itſelf, and draw the water from thence by a force pump (or any more convenient hand machinery) into the engine Shaft; this, however, is ſeldom done unleſs a Mine is ſoon to be ſet idle. If the Lode underlies north, the engine Shaft ought to be at a good diſtance north from the back of the Lode; becauſe, while the engine is drawing the water out of the Shaft, the Lode is ſtill coming nearer to it by every fathom of Lode or ground that is broke away, until at laſt the Lode underlies into the Shaft itſelf; and in proceſs of further ſinking the Mine, the Lode which was before to the ſouth of the Shaft, is gone through to the north of it; ſo that the deeper either of them is ſunk, they are more and more diſtant from each other, and become at laſt very expenſive and incommodious from the unavoidable neceſſity they are under, of continually driving a Croſs-cut, or Drift, from one to the other, that the water may flow into the Sumph for its diſcharge to Adit. This is an evil that cannot be prevented; for, in all deep Mines, their engine Shafts, at laſt, muſt be very diſtant from their Lodes, unleſs the underlie is trifling, and the Lode very little removed from a perpendicular. This Croſs-cut or Drift of Communication is ſometimes very tedious and expenſive, where the ground is hard, the water quick, and the engine almoſt at the extent of its power.

Plate 3.



To John County of CORNWALL.

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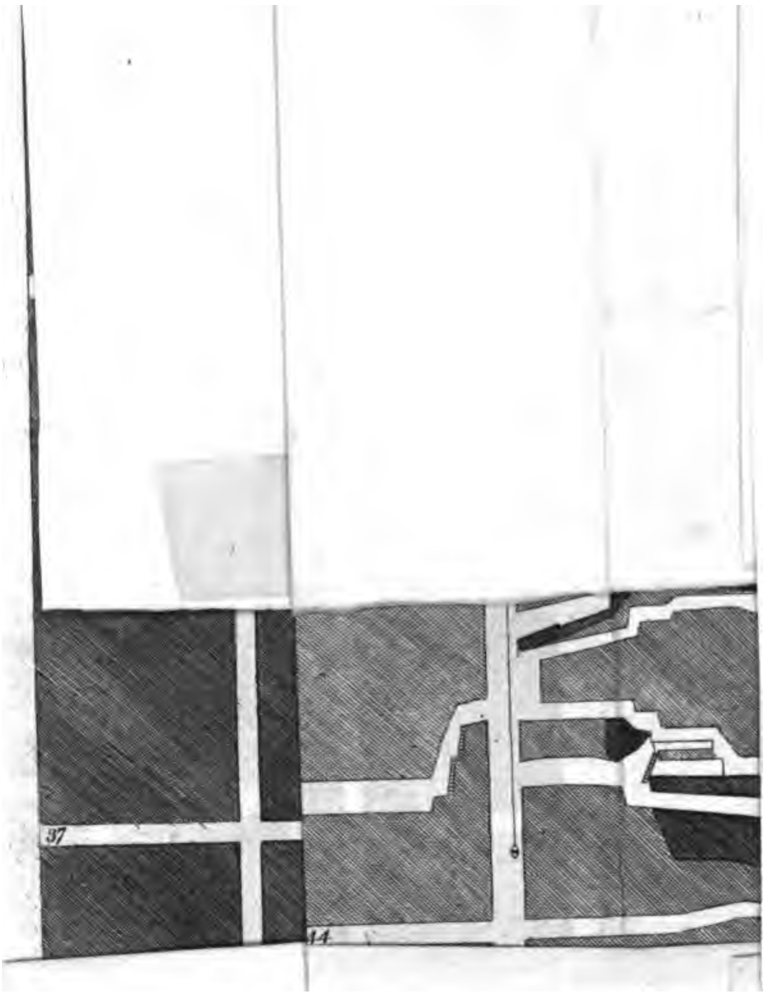
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part, and three T the Tributors. This, however, is not all; the adventurers three doles and a quarter are again divided into eighths, ſixteenths, thirty-ſeconds, and ſixty-fourths, and even much ſmaller fractions, that each may know and carry away his own.

The Tributor again has ſeveral perſons concerned with him, who redivide their ſeven Doles and three quarters in like manner: and thus are theſe fractional complicated diviſions, which at firſt ſight would puzzle the moſt expert arithmetician, effected by our illiterate Tinners upon the ſimpleſt plan, and with the utmoſt dexterity, diſpatch, and accuracy. To any other but a Corniſh reader, it may appear ſtrange, that ſo much trouble ſhould be taken in dividing and redividing the Tin-ſtuff in this manner, when it might be carried and returned altogether, and the proportions reckoned in money; but this cannot always be done; for ſtamping mills are numerous, and the ſeparate eſtates of ſeveral people, whoſe value riſes in proportion to the uſe and employment they have for them; therefore if the Tin-ſtuff is rich, every one is ready to carry off his reſpective Dole or ſhare, immediately after it is divided out, and the lots are caſt.

The ſetting of a Copper Mine upon tribute, has this difference: the Tributor is at the ſole expence of digging, raiſing, and dreſſing, all the Ore that can be made merchantable; and the proceeds of ſales are received by the adventurers, who pay the Lord his one-ſeventh, one-eighth, or one-tenth part, which ever it is, in money. If it is one-eighth, that is two ſhillings and ſixpence out of every pound or twenty ſhillings, of the remaining ſeventeen ſhillings and ſixpence the adventurers may have eight ſhillings, and account to the Tributor for the reſidue, which is nine ſhillings and ſixpence: and thus, it is ſaid, "Petherick Kernick of Hantergantick, Abednego Baraguanath "of Towednack, Dungey Crowgie of Carnalizzy, and Degory "Tripeoney of Gumford, have jointly taken a Copper Mine "upon tribute for nine and ſixpence out of the pound."

When the adventurers thus ſet a Mine to farm, they oblige the Taker or Tributor to keep the Mine in good repair, and well ſecured with whatever timber is needful; the putting of which into the Mine, ought to be according to the ſkill and diſcretion of a perſon deputed for that purpoſe by the adventurers. They alſo ſtipulate with the Taker of the Mine upon tribute,

tribute, to work it regularly with a certain number of men; but not in dippas, holes, and corners, to encumber the adventurers, at their re-entrance into the Mine, with the charge of breaking and clearing the barren part or deads, which the Tributor would otherwiſe leave under-ground. It is very reaſonable that the Tributor ſhould be obliged to deliver up the Mine in good order and condition, at the expiration of the time ſpecified; and that the adventurers ſhould reſerve to themſelves and agents, a power of going down into the Mine at will, to examine if the premiſes be duly complied with and fulfilled.

So far we have been ſpeaking of a whole Mine, taken upon tribute; but it is much more common, and has been always the caſe in large Mines, to ſet ſeveral parts of them in ſmall portions of ground called Pitches. A Tribute-Pitch, conſiſts of a few fathoms in length on the courſe of the Lode: two Pitches may meet half way between two Shafts, and draw their Ore to that Shaft, with which either of them are connected. If a Pitch is high up in the Mine at a ſhallow level, it is called a Pitch upon the Backs; but if lower down, in or joining with the bottoms, it is called a Bottom-Pitch. The time they contract for is generally four months, and to work the Pitch at all working times, in a regular manner with a certain number of men. The Tributor is obliged to work one month, or forfeit to the owners twenty ſhillings for every man he is obliged to employ; in lieu thereof, if he does not chuſe to continue at the month's end, he declines the occupation of his Pitch, and forfeits to the adventurers all the Ore which ſhall be broken.

The boxes and clacks or valves of the engine pump often go amiſs, and if they are not made of good leather well ſewed, a misfortune of that nature will happen almoſt every day; ſo that every method muſt be contrived, to have aſſiſtance at hand to man the capſtan, while a clack or a box is changing. Accordingly, a Tribute-Taker, as well as every other Miner in a Bal, obliges himſelf and partners to lend a hand gratis at the capſtan whenever required, upon the penalty of two ſhillings and ſixpence for each perſon reſpectively who refuſes his aſſiſtance. Without a regulation of this kind, a Mine would be in danger of ſetting idle, for want of neceſſary help: but when they cleanſe a boiler, which is once a month; or drop pumps, that is, let them down into the Mine; the adventurers charge each man at the capſtan a ſtem or a day's hire, and give them ſome

 additional

additional recompence if the weather is ſevere, or they make a long day's work.

The Takers of Tribute-Pitches in a Copper Mine, are likewiſe obliged to mix their Ores with thoſe of other Pitches, or with the owners Ores; and to ſample the ſame according to the will and diſcretion of the Captains; elſe the parcels of Ore would be very ſmall, where they may be twenty Pitches upon tribute in one Mine. Before the parcels are mixed together, they take from each a fair honeſt ſample, and mark them A, B, and ſo on, which they call private ſamples. The aſſay-maſter, who buys at the publick ticketing or ſale a mixed parcel of Ore, hath theſe private ſamples given to him, which he aſſays for two ſhillings and ſixpence each with all the judgment and dexterity he is capable of, to make the moſt of each; and it is a very rare thing for any complaint or diſſatisfaction to ariſe from the appropriate diſpenſations of our aſſayiſts, ſo expert are they in their buſineſs.

The uſe of private ſamples is this: though the ſundry parcels of Ore which are mixed together for ſale, may appear nearly of one value at ſight, yet it muſt neceſſarily follow, that ſome difference will ariſe from different management in the dreſſing and other accidental cauſes. In a mixed parcel of fifty tons, A may have twenty of fifteen pounds value ℔ ton; B may have twenty-five of fourteen pounds ten ſhillings; and C may have five of ſixteen pounds ℔ ton, according to the private ſamples; yet the groſs fifty tons may ſell for fifteen pounds five ſhillings ℔ ton. Nevertheleſs the amount muſt be divided among the Tributors according to the ſelling price, ſubject to a regulation by the private ſamples; that is, the exceſs or diminution, for what it ſells, muſt be proportioned by the produce of the private ſamples; for, if fifty tons ſell at fifteen pounds five ſhillings, the amount is equal to ſeven hundred and ſixty-two pounds ten ſhillings. Purſuant to the above private ſamples

	£.			£.	
A's 20 tons at	15	—	=	300	—
B's 25 ——	14	10	=	362	10
C's 5 ——	16	—	=	80	—
The amount				742	10
which is				20	ſhort by the private ſamples.

This is called £20 increaſe by 762 10 which it ſold for.

Now

Now the method of proportioning this twenty pounds increase, is done by the rule of three direct, thus:

	£.		£.	£.		£.			
If	742	10	20	300	—	A 8	1	7¼	increase
If	742	10	20	362	10	B 9	15	4	increase
If	742	10	20	80	—	C 2	3	0¼	increase
				742	10	add 20	0	0	
						Amount £762		10.	

Here it is evident, that if the Adventurers were to account to the Tributors at the private prices, they would deprive them of twenty pounds of which they ought to have their respective proportions, it being the absolute value for which the commodity was sold. Also, by mixing these three parcels, they have altogether brought a better price by twenty pounds, than if they had been sold separately.

The interchange of terms in this matter is very applicable, and easy to be reconciled; for in case of a decrease, that is, if the selling price had been seven hundred and sixty-two pounds ten shillings, and the private samples had exceeded that by twenty pounds, making the whole seven hundred and eighty-two pounds ten shillings, then the method of solution would be the same by the rule of three, deducting each ones particular share, according to the amount of his Ore.

We may further illustrate this matter, by entry of an account of Ores, sold and proportioned to the Lord, Adventurers, and Tributors.

Dolcôth Copper Ores weighed the 24th of March 1777.

Quantity	Price ꝑ Ton	To whom sold	Amount	Lord's pt. 1-seventh	Adventur. net part
Tons ꝑ Q.	£.		£.	£.	£.
21 10 2	10 —	Cornish Copper Comp.	215 —	30 14 3	184 5 9

Tributor's Account of the above Ores.

Quantity	Price	Amount	Increase	Amount	Tributors Part	Tributors Money
Tons ꝑ Q.	£.	£.	£.	£.	S. S.	£.
A 10 10 2	11 —	115 10	3 6 4	118 16 4	5 from 20	29 14 1
B 11 — —	8 10	93 10	2 13 8	96 3 8	10 — 20	48 1 10
21 10 2	Sold at £10 ꝑ Ton £215					

By

By this time, I preſume, the reader has a pretty clear conception of the affair, and that each ſhare of the £215 ſtands thus:

The Lord's one-ſeventh -	£30	14	3	£215
The Tributors - - - - -	77	15	11	
And the Adventurers net part	106	9	10	

The ſpirit of adventure hath many times ſo prevailed among the lower people, that very large ſums have been won and loſt by this kind of gaming, much to the injury of the caſhiers, who can have no recompence from poverty and rags. It is a method that will always anſwer for the adventurers, provided the Takers upon tribute will execute their part and fulfil their articles of agreement, which it is difficult for the adventurers to compel them to perform. Theſe reaſons have induced the adventurers in ſome Mines, to ſet their Tin and Copper Ore to break by the fathom; and I believe it is productive of more certain wages to the men, and larger quantity of Ore to the owners; which is of conſiderable importance to a Mine, obliged to ſupport a monthly charge of eighteen hundred or two thouſand pounds. It would be well if the Takers of Pitches on tribute, would allow ſo much in their calculations for the decay of a Lode; for it is generally known thoſe people commonly take a rich bunch of Tin or Copper Ore upon tribute according to its full value in ſight, not conſidering, perhaps, that it is almoſt impoſſible for ſuch to be richer; and that it is great odds whether it may continue half ſo rich for the limited time. This want of precaution plunges them into many difficulties, when an alteration of the Lode happens from riches to poverty: and, indeed, any perſon may conclude, that little more than common wages can be gained, by working a Pitch for twelvepence in the pound. Nevertheleſs, I have known ſeveral wrought at that value; and many ſcore tons of Copper Ore raiſed out of North-Downs Mine at tenpence, for which a ſhaft in that Mine bears the name of Tenpenny-Shaft (ſee North-Downs plate). But my readers will wonder more when I declare, that I have known ſeveral hundred tons of Copper Ore wrought and dreſſed for fivepence halfpenny in the pound, at Huel-Virgin Mine: this, however, muſt be underſtood to have been the caſe, when the commodity brought a better price by thirty ℔ cent. than it now bears: which obſervation ſuits with the decreaſed value of Tin as well or more ſo; for it is equally true, that where I have been formerly concerned, as part owner of a Tin Mine, we have ſet a Pitch to be wrought for

be a great inſtance of the efficacy of contagion in one derivative habit of body. Some part of our Mining diſtrict is ever moleſted by ſuch violent fevers: one or other of the pariſhes of St. Agnes, Kenwyn, Kea, Redruth, Gwenap, Stithyans, Wendron, Sithney, Breage, Crowan, Gwinear, Camborne, and Illugan, have epidemick fevers always among them.

Mineral exhalations are allowed to be one cauſe of contagion, and, Mr. Boyle ſays, even of the plague itſelf: my principal deſign, therefore, is to prove the obnoxious ſituation of our Mine country to thoſe dangerous diſeaſes; and from thence to infer, that they are with us the peculiar production of Mineral effluvia. If this is not the caſe, I ſhould like to be informed what occaſions thoſe diſorders to rage with ſuch violence among us, and be endemial to our Mining pariſhes? Perhaps it may be ſaid, they are produced by the unwholeſome and uncleanly manner of living among the Tinners. But I have known them to originate in the moſt cleanly healthy families; nay, it is notorious, that the more regular livers, and more delicate inhabitants of this town, have more generally and powerfully experienced their attacks.

In December 1772, particularly at the time of the poll for a knight of the ſhire, we had a warm moiſt atmoſphere for three weeks, without rain, or a currency of air ſufficient to blow out a lighted candle. Soon after, nervous and malignant fevers were very rife, and were generated I apprehend by thoſe Mineral effluvia, which, in that month, by means of the foregoing conſtitution of the atmoſphere, were ſuſpended for a conſiderable time, and particularly affected thoſe perſons whoſe nervous ſyſtem was very weak and lax, or thoſe of quick and lively ſenſations; while ſuch as were athletick, robuſt, and ſanguine, generally eſcaped their peſtilential influence. Again; it was obſervable, that the weather, in December 1774, and in the beginning of January following, was unſeaſonably warm, ſerene, and mild; the air for three weeks before was ſcarcely agitated by one breeze, but continued, all that time, warm, moiſt, and vapid. The writer then predicted the conſequential malignant effects which happened ſoon after; and he thinks any one may foretel the eventual incidents that muſt follow ſuch continual unſeaſonable weather, in a country teeming with Metals and Minerals. But it is time to come nearer to the point in hand, and to ſhew, that we are obnoxious to poiſonous Damps underground, notwithſtanding the preconceived notion of many to

the Van is bruised fine and washed, they lay the shovel over the fire, and burn the black Tin, continually stirring it till it smokes no more. Lastly, they wash it again on the shovel, and so the brood is carried off by the water, it becoming light by being burnt; for when black Tin is calcined or burned, it still retains its specifick gravity; but Copper, Lead, and other crude Minerals, become much lighter by torrefaction, and are easily separated from the Tin by water.

It should be observed, that each sack ought to hold twelve gallons of Tin-stuff, though they often hold but nine or ten; which want of measure, when known, should be taken into consideration by the Tin buyer.

Now, whoever intends to buy a quantity of Tin-stuff, either for profit in trade, or merely for the sake of employing his stamping mills, horses, and labourers; when his adventure Tin-stuff falls short, which is very commonly the case, he must not give the value of its full produce, without deducting what is called the returning charges, that is, the carrying, stamping, and dressing thereof. On the other hand, the reader must be apprised, that the value of Tin-stuff, is short of its intrinsick worth by the Van only; for in the dressing and management of Tin by stamping, &c. there are two sorts of black Tin to be obtained, viz. the crop and rough, or the crop and leavings of Tin. The first is the prime Tin, immediately separable from the baser parts by its superior weight and richness; the latter is that which is carried off, and mixed with the lighter earthy parts, by its being under size, and therefore more susceptible of the force and impression of a determinate stream of water. Such Tin being composed of the most slimy moleculæ, as well as of the larger rough grains, which get through the greater sized holes of the stamping-mill grate, have very little Tin in them, and must therefore undergo another treatment to get out and cleanse the Tin. This being called the leavings, must be accounted for and valued in addition to the crop Tin, in proportion to the dense or lax consistence of the Tin-stuff and the specifick granules or minutiæ of the Tin Ore in the stone. All this depends upon the experienced judgment of the Tin-dresser; and it is so difficult and various a subject, that a man simply a theorist in the matter, cannot lay down a certain rule on which another can absolutely depend. The customary valuation is, by setting a price upon the leavings of this or that Tin-stuff, according to so much the ten hundred weight or thousand

thousand it makes in crop Tin, from fifty shillings to five pounds ℔ thousand for the leavings. Hence it follows, that the leavings of some Tin-stuff will more than pay the returning charges; but whenever the leavings are rich enough to pay those incumbrances, they pronounce such Tin-stuff to be "Tin in the "Bal;" that is, to be worth four, five, or six hundred of white Tin ℔ hundred sacks by the Van, free of all costs and charges, which the leavings will exonerate.

All things being well considered, we may conclude, by trying the sample, how to size a parcel of Tin-stuff by suiting it with a grate or holed plate, adapted to the natural grain of the Tin, which is one of the principal articles in dressing; but of this in its place. Mean while let us observe that the dressings of Tin in its present improved state, has been very lately invented; for by Mr. Carew's account, no longer back than one hundred and eighty years, in queen Elizabeth's reign, the manner or dressing was exceeding slovenly; and I am very sure, notwithstanding our present advance, we are yet at some distance from perfection in that art. He says, "As much almost dooth it "exceede credite, that the Tynne, for and in so small quantitie "digged up with so great toyle, and passing afterwards thorow "the managing of so many hands, e're it come to sale, should "be any way able to acquite the cost; for being once brought "above-ground in the stone, it is first broken in pieces with "hammers; and then carried, either in waynes, or on horses "backs, to a stamping-mill, where three, and in some places "sixe great logges of timber, bounde at the ends with Iron, "and lifted up and downe by a wheele, driven with the "water, doe break it smaller.

"The streame, after it hath forsaken the mill, is made to "fall by certainne degrees, one somewhat distant from another; "upon each of which, at every discent, lyeth a green turfe, "three or four foot square, and one foot thicke. On this the "Tynner layeth a certayne portion of the sandie Tynne, and "with his shovel softly tosseth the same to and fro, that, thro "this stirring, the water which runneth over it, may wash "away the light earth from the Tynne, which of a heavier "substance lyeth fast on the turfe. Having so cleansed one "portion, he setteth the same aside, and beginneth with "another, untill his labour take end with his taske. After it "is thus washed they put the remnant into a wooden dish, "broad, flat, and round, being about two feet over, and

"having

" having two handles faſtened at the ſides, by which they ſoftly
" ſhogge the ſame to and fro in the water between their legges,
" as they ſet over it, untill whatſoever of the earthie ſubſtance
" that was left, be flited away. Some of later time, with a
" ſleighter invention, and lighter labour, doe cauſe certayne
" boyes to ſtir it up and down with their feete, which worketh
" the ſame effect: the reſidue, after this often cleanſing, they
" calle Black Tynne. But ſithence I gathered ſticks to the
" buildinge of this poor neſt, Sir Francis Godolphin enter-
" tained a Dutch Mynerall-man, and taking light from his
" experience, but building thereon far more profitable conclu-
" ſions of his owne inventions, hath practiſed a more ſaving
" way in theſe matters, and beſides, made Tynne with good
" profit of that refuſe which Tynners rejected as nothing
" worthe." Thus far Mr. Carew.

Seeing that a dreſſer's judgment is required in the choice of a grate, I begin with a deſcription of that firſt and neceſſary part of a ſtamping mill, which is a thin plate of Iron one-tenth of an inch thick, and twelve inches long by ten wide. The middle of this, from eight inches and an half by ſeven inches, is punched full of holes from the diameter of a ſmall pin, to that of a large reed; for the larger the Tin cryſtals incloſing the Metal are, ſo much the more capacious muſt be the holes, and vice verſâ. This holed plate, commonly named the Grate (I preſume from the cuſtom formerly of diſcharging their ſtamped Tin through grates or iron bars) is nailed on the inſide of the frame, at Y, plate V, near the bottom where the ſtamp heads pound the Ore. The Tin-ſtuff being depoſited on the floor, at C, called the Garden of the Paſs, from thence it ſlides by its own weight, the motion of the ſtamps tackle, and the aſſiſtance of a ſmall rill of water, D, into the box at Y; there by the lifters a, b, c, falling on it, after being raiſed by the axle-tree, d, which is turned round by the water wheel, B, it is pounded or ſtamped ſmall. The lifters are three to each ſtamps, made of aſh timber, ſix by ſeven inches ſquare, and about nine or ten feet long. They are armed at the bottom with large maſſes of Iron called Stamp-Heads, of one hundred and forty pounds weight in each, or more: theſe are lifted up, and let fall, between two upright parallel planks of oak timber, by wooden knobs or teeth, called Caps, fixed in the barrel of the axletree at proper diſtances, and in number proportioned to the circumference of the axis, which goes round by the power of the water wheel. Thoſe caps in their round, take up pieces of

other Semi-Metals; for ſometimes we meet with all theſe ſorts of Minerals intimately blended in one and the ſame ſtone of Tin Ore; which being ſpecifically heavier than the Tin, whatever Tin-ſtuff is incorporated with theſe muſt be burnt to evaporate the ſulphur, arſenick, &c. after it is firſt ſtamped, dreſſed, and cleanſed from its earthy ſordes, in the manner before deſcribed, in order to make it fit for calcination in the furnace, called a burning-houſe.

A burning-houſe much reſembles a ſmelting-furnace, but not in every particular. The furnace is built without doors, at one end of the houſe, where the chimney is raiſed to carry off the ſmoke and ſublimate of the calcined Minerals. The houſe ſerves no other purpoſe than that of a covering for the man who rakes the calcining Ores, and the preſervation of ſome few tools that would be unſafe out of doors.

The foundation of the furnace is built of hewn moorſtone about four feet and a half high, on which the bed or bottom of the furnace is laid. Under the bottom, a little towards the houſe where the man ſtands to rake the Tin, is left a hollow place for holding the Tin after it is burnt, which they call the Oven, that will contain about ſixteen or twenty Wincheſter buſhels, with an opening on that ſide next the ſtamps plot, in ſhape and ſize much like a ſmall chamber chimney, in order to come at and take out the calcined Tin, which is let down through an orifice in the bottom of the furnace adjoining to the houſe. Except at this orifice, the oven is arched over to lay part of the furnace bottom upon. The top, bottom, and hewns (ſides) of the calciner were formerly made of moorſtone wrought very fine; but brick is now moſtly uſed, it being more durable for fire work than ſtone. The length of the calciner is generally about nine feet, and the width five in the belly or middle, gradually decreaſing towards the chimney or houſe to ſixteen inches, and towards the grate or fire place to three feet, which is at the further end directly oppoſite to the houſe and chimney. The hewns, or ſides, are about ten inches high; upon which is turned a flat arch or covering, which includes the fire place alſo. This grate or fire place is about ten inches wide, and three feet long; at the ſide of which, between it and the furnace, is a brick thick partition or bridge three inches high, to prevent the Tin from mixing with the coal. Over this bridge the fire conſtantly reverberates upon the matter in calcination, while the ſmoke and ſulphur aſcend the chimney at the houſe-end

hand barrows full of ſlime, where it mixes with a little rill of water that floats it down into the ſemi-circular pit P called the Head or Pednan, wherein a boy treloobs or ſtirs the ſlimy water round about with a ſmall ſhovel, that the water may waſh away both the filth and Tin over a croſs board ten inches deep at the lower part of the pednan: the board is ſomewhat lower in the middle than at each end, for admitting the watery mixture with more eaſe into the body of the trunk O, R, R: that which reſts in the fore part of the trunk at O o, is carried off to be framed, and the ſettlement at R, R, is moved forwards to P, to be trunked over again before it is fit for the frame: the rough grains lie at the bottom of the ſtrêk, whence it is removed for ſtamping, and the moſt light and ſmall ſlime paſſes the bottom or lower end of the trunk into a pit, where it ſettles and acquires the name of Loobs.

The frame or rack T W, conſiſts of two inclined planes of timber; the body W, the head T. The frame is an oblong ſquare eight feet by five, with ſides four inches high, all joined cloſely, that nothing may eſcape but at the extremity or lower end. At the middle of the two ends are fixed two round projecting irons called Melliers, by which the frame hangs and turns as it were on an axis, upon two upright pieces of timber one at each end, whereby the frame may be ſwung up and down, perpendicular to the horizon. The head T, is two boards wide, and in length parallel to the breadth of the frame. To the bottom of this is joined a water head, or board, ſeven inches high; to which is hung, by hinges, a ſlight piece of board ſix inches wide, and the length of the head, called the Lap, or Lippet, whoſe uſe is to convey the water and Tin equally down upon the frame. Underneath the fore part of the frame, is fixed a little tray or cheſt three feet long, called the Kôſer, and another at its lower end called the Hind-Kôſer.

The water falling in a gentle manner from S upon the head T, waſhes the Ore, which there offers itſelf (as at the buddle) in little ridges, downwards over the lippet, upon the body of the frame W. On this frame the water is ſpread ſo thin, and runs ſo ſlowly, (the plane being very little inclined) that by moving the ſlimy Tin to and fro with a light hand, and expoſing it cautiouſly to the water by a ſmall ſemi-circular toothleſs rake, all the ſordes are waſhed away, and the Tin though ever ſo ſmall, remains on the frame near the head. When the Tin is found ſufficiently clean, the body of the frame being hung on melliers,

melliers, as I have ſaid before (by ſlipping the ſtake underneath, which ſupports it) is turned eaſily from horizontal to perpendicular; and the Tin which remains on the frame runs off, by the aſſiſtance of a little ſprinkling, in two degrees of purity, into the fore and hind kôfers. The frame is then righted into its horizontal poſitions, and the proceſs repeated till the kôfers are full. The ſmaller ſlime, which runs off the lower end of the frame, is yet preſerved in a pit by the name of Catchers, and makes a part of the loobs or leavings of leavings, to be worked over again at a future time. The contents of the fore kôfer is then ſifted through a fine hair ſieve or copper bottom, into a keeve with water in it, to ſeparate the gravel, chips, or any other accidental mixture from it. Then it is buddled and ſaved in different portions, like crop Tin; as well undergoing the ſeveral operations of toſſing, packing, ſkimping, dillhuing, &c. After all, if the Tin is very ſmall, it is carried to the frame again, and reframed or cazed, as they term it; which is performed, by ſtoping the lower end of the frame with mud and turf, that the water may be almoſt ſtill, and the Tin more eaſily ſettle upon the frame, and deſcend the more ſurely into the kôfer: the fore kôfer is then emptied the ſecond time, the Tin carried to the keeve again, there toſſed, packed, ſkimmed, &c. and thus the ſlimes are finiſhed, and brought to as great a degree of purity, as the ſize of the Tin will permit, which being exceeding ſmall, will neceſſarily have ſomewhat more of waſte, than what is larger and heavier.

The great pile of tails behind the buddles, are commonly waſhed down into the trunk below, by a pretty ſtrong current of water, which may be rendered more or leſs forcible by an alteration of its fall, to divide the rough from the ſmall, by treloobing them in the ſemi-circular kôfer of the trunk with a ſhovel. The ſmall that flaſhes over into the trunk, is deſigned for framing, and ſo divided into two parts, the fore, and the hind kôfer. The latter muſt be toſſed and framed again; but if the fore kôfer is pretty good, it may be toſſed and packed, the ſkimpings of which muſt be cazed in the buddle, that is, one perſon buddles it as uſual, but with a very ſmall ſlow ſtream of water, while another with a few quils fixed on the end of a pole, lightly ſweeps the buddle acroſs from ſide to ſide, beginning at the bottom, and ſo proceeding forward every ſtroke, till he comes to the breaſt of the buddle, when he returns in like manner progreſſively to the end or tail. By this method it is made fit for cleanſing in the keeve, &c. and the hind part, that

that is not fit for toſſing, &c. muſt be framed again, and proceeded with in the former manner.

Mean time, all tails that are taken from the bottom of the trunk head or pednan, together with the roughs (or rows) that come from the ſlime, or from the toſſings of the hind and fore kôfers, that are not of a proper ſize, muſt be ſtamped over again, and dreſſed in the manner before mentioned for bringing about the crop Tin or bal work. But in the ſtamping them, care muſt be taken to ſuit them with a proper grate and ſmall weight of tackle, or worn old ſtamp-heads; otherwiſe they may be ſtamped under ſize, and choak the grate, which they call being dumbed; to prevent which, they mix with them a ſmall quantity of Goſſan or poor Tin-ſtuff, to cut and jagg them up, elſe the ſtamp-heads would mudify them too much to paſs the grate holes as freely as they ought: nay I have known common Quartz uſed for this purpoſe, entirely deſtitute of Tin. If there be a corrupt brood in the leavings Tin, ſo as to damage its value two parts in twenty, it muſt be burned in the manner before directed, but with a leſs violent fire, and then dreſſed again from its calcined impurities: the calcination of leavings Tin ſhould, however, be always avoided if poſſible, becauſe it is ſo fine, like floran Tin, that it will, by its ſized levity, be elevated and carried off, together with the arſenick and ſulphur.

The modes of dreſſing Tin and its leavings, are too various to lay before the reader, without danger of prolixity: all of them depend upon the difference of the kinds of Tin in the ſtone, and muſt be dealt with, agreeable to the judgment of ſeveral manufacturers. So much depends upon the ſkill of a dreſſer, that one may ſave one-twelfth part of a batch of Tin, which another for want of equal knowledge may caſt away in waſte, or perhaps take up ſo much waſte with it, as to depreciate the value of the whole by two parts in twenty. Nevertheleſs, all dreſſers ſave the hinder ſtuff from the frame end, as it waſhes off in a pit by the name of Catchers, which is expreſſive enough; and likewiſe the mud at the trunk ends, by the other name of Loobs, both of which are denominated the Loobs, after leavings, or leavings of leavings. Theſe are wrought over in the ſame manner as the former, moſtly upon tribute, by an aged workman and a few little boys in the ſummer months, when they can ſtand out in good weather, and do a long day's eaſy labour. The tribute paid by the undertaker is one-third of the produce in white Tin; the other two-thirds he has for himſelf to pay his coſt and charges.

Proceeding upon this ſingle principle, that the force of water, properly applied and introduced among the particles of Tin Ore and the ſordes mixed with it, will diſperſe the latter and leave the former at reſt for them to collect and treaſure up, they vary their operations inconceivably, conducting them with great ingenuity, leſſening, encreaſing, diffuſing, or contracting their water, the great inſtrument of purity, as the ſize, weight, and combinations of the Metal and its feeders require; and that with great eaſe, cheapneſs, and regularity, throughout the ſeveral proceſſes.

Hence, this buſineſs of dreſſing is a particular trade, entirely different from that of the labouring Miner; and is beſt learned under a maſter workman, who makes it his ſole occupation to follow the ſtamping mill and the works belonging thereto. This maſter workman hires boys from ſeven years old to eighteen, gives the former about three ſhillings a month, and raiſes their wages as they advance in years and workmanſhip, till they have man's wages, viz. at the leaſt twenty-four ſhillings, at the higheſt thirty ſhillings ℔ month. This is of double benefit to the poor parents; and the boys being taken in ſo young, become healthy and hardy by uſing themſelves to cold, and to work with naked wet feet all day; and they learn early to contribute to their own maintenance. Each ſtamping mill which has conſtant work and water, will employ one man and five boys; and one hundred ſacks are carried, ſtamped, and dreſſed, in the ſpace of a few days, at the average rate of about fourpence ℔ ſack, or one guinea and a half ℔ hundred.

We ſhall here obſerve, that even burnt leavings of Tin are often conſiderably valuable, eſpecially if they are cupreous; and even the pooreſt of theſe leavings bring ten or twenty ſhillings ℔ ton; which is better than to throw them away, as was the caſe no further back than forty years. All burnt leavings taken from Tin-ſtuff, till the year 1735, were eſteemed good for nothing. But in that year there were ſeveral ſmall parcels lying on ſundry ſtamps plots in this pariſh, which induced Mr. Morgan Bevan, an old experienced aſſayer, to try whether he could reduce them into Metal. For the firſt time he aſſayed a ſample of three tons; and, to his own great ſurpriſe, as well as that of others, he found that he could give ſeven pounds four ſhillings and

and ſixpence ℘ ton for them, which he actually did, and preſently after bought ſeveral parcels more of Meſſrs. Carter, Reynolds, Penroſe, Corniſh, &c. the principal Tin dreſſers of thoſe days. From that time all burnt leavings were taken much care of, provided they were ſufficiently impregnated with Copper; for ſome of them are merely Mundick, with little or no Copper in them. When the Braſs-wire Company carried on the great Tin Mine of Chacewater, before this diſcovery they caſt away ſome hundred tons of burnt leavings, to their great prejudice; but ſince that time there have been large quantities ſold from the ſame Mine.

The very water in which burnt Tin is waſhed, may be converted to a uſeful and profitable account, either by evaporation to a pellicle for cryſtallization of Copper, commonly called Blue or Roman Vitriol; or for the precipitation of Copper by the medium of Iron, laid in veſſels filled with this vitriolick water. The precipitation of Copper by Iron, is too generally underſtood to make an explanation neceſſary here; but we have obſerved among our Copper precipitate, where it has been effected by a very ſtrong ſolution with the cleaneſt Iron, ſeveral pieces of malleable Copper, ſome of them retaining the form of the Iron, like incruſtations fallen off from it. Hence it ſeems as if there was a degree of attraction between the Iron and the particles of Copper, floating in the water; as well as the more obvious attraction between the acid and the Iron. Muſt not the particles of Copper thus attracted, cohere by their own magnetiſm, or the attraction of coheſion?

It may not be improper to add how far this quality has already tended or may tend to the advantage of the publick. Perhaps the hiſtory of its riſe and progreſs in this country, and in Ireland, may ſerve to illuſtrate that matter. About ſixty years ago, this phenomenon was firſt obſerved by Mr. Coſter in Chacewater Mine near this town; for after he had drawn out the water, which had been in the Mine for ſeveral years, he found the poll of a pick-axe wholly encruſted with a caſe of malleable Copper between two and three pounds weight. This it was juſtly ſuppoſed was obſerved by the workmen, ſome of whom afterwards ſettled at Cranbaun Mine in the county of Wicklow in Ireland. The water of Cranbaun having this vitriolick acid in a very high degree, Capt. Thomas Butler, who was one of Redruth, and manager of that Mine, perſuaded the proprietors to adopt the ſcheme of precipitating Copper, of which

which they have made for many years paſt and now continue to make very conſiderable profit. They dig pits at proper diſtances in the Adit, (or ſo near as to admit the water) in which pit they place wooden rails, ſomewhat like a bottle rack, ſo as to ſuſpend the Iron thereon. They put in many tons at a time; and, in about ſix weeks, the Iron is totally diſſolved. The precipitated Copper is then taken out, fit for ſale; the greateſt part in the form of our Goſſan pounded, with ſeveral grains of pure Copper interſperſed.

An attempt of this kind was ſome years paſt made in Huel-Crafty, but without ſucceſs; for the water being in one part of the Mine only, and in no greater quantity than would run through a quill, was too much diluted by other water mixing with it in the hutch where the Iron was placed; beſides, the Iron itſelf was very ruſty which will always obſtruct the ſucceſs, unleſs the water is in the higheſt degree impregnated with the acid. A ſmall and ready experiment proves this; for take a bright piece of Iron, ſuch as a key, or poliſhed knife, and immerſe it in the water for half a minute, and it will be ſtained of a Copper colour. Many Mines in this county have ſome rills of this water, ſo as to do conſiderable miſchief, without having as yet (perhaps for want of proper attention) applied it to this uſe.

But though we may date the firſt hints relating to this matter in England and Ireland from the foregoing diſcovery in Chace-water, it is no new thing in other countries. Brown mentions it in his travels into Hungary, as a profitable appendage to the Mining of that country. Dr. Rutty, in his Natural Hiſtory of Dublin, ſays, " Our water at Cranbaun in the county of " Wicklow, may well vie with thoſe of Herengrund and Ciment " in Hungary. Of ours I received the following account in the " year 1765 from a perſon converſant in theſe matters."

" It is ſaid to tranſmute Iron into Copper; but the fact is, " that it precipitates its contained Copper upon Iron bars im- " merſed. It continues in its full ſtrength; and, in ſeven years " laſt paſt, yielded to its proprietors a ſum no leſs than ſeven- " teen thouſand two hundred and fifty-nine pounds eighteen " ſhillings and ninepence halfpenny, and all this without any " expence of fuel and men. The precipitate thus formed being " fluxed, yields above half of pure Copper: for an ounce gave " twelve pennyweights and eighteen grains in one experiment, " and thirteen pennyweights twelve grains in another."

whofe contents are lefs than half a ton ℔ hundred facks, it is fcarce worth the trouble of returning and dreffing it, except the Ore is rich in quality, and will bring a good price: much alfo depends in this cafe upon conveniencies, care, and expence more or lefs in carriage and water to drefs it.

Halvans ftamped fmall, and then wafhed in a ftrêke with an eafy ftream of water, is termed Stampt Ore. But a finer fort is ftill to be had from the flime pit, which proceeds from the minute particles that glide away with the mud and water; this fort will not bear a brifk ftream, therefore it ftill retains much dirt and mud, whence it is called Slime Ore. The rough part of ftampt Ore fhould be tyed in a ftream of water, and the hinder part of the tye jigged through a fix or feven hole fieve. If it is much adulterated with Tin, Lead, or Mundick, it muft be cleanfed by frequently tying or buddling of it. In order to clear the earthy fordes from the flime or loobs, it may be trunked, and after purified by the buddle, kieve, dilluer, &c. the fame as flime Tin, if it is worth the expence. It muft alfo be noted, that Copper Ore requires a coarfer plate or grate in ftamping, than Tin does, becaufe it is of a lighter nature and more fleaky.

I have heard of a poor fandy Copper Ore fomewhere in Wales, of the appearance of verdigreafe, which is fo light, that the cupreous part of it will not bear even the leaft ftream of water: they drefs it by grinding, dry ftamping, or bucking; then put it into tubs or kieves, and tofs and pack it the fame as I have obferved of Tin: now the real Ore in it being without any fulphur, or much Metal, is fpecifically lighter than the wafte or fand; therefore the Ore fwims uppermoft, and is fkimmed off in the manner of Tin fkimpings. But I fuppofe thofe extreme light Ores are fo very poor, that none would be concerned with them, only in hopes of their improvement.

It is worth notice, that Copper Ore may be too curioufly or too remiffly dreffed, fo that either way the adventurers may incur a lofs; the ground of which is fometimes not fo well confidered as it deferves. If too much time and coft are expended in dreffing the Ore, every one will grant it infers a lofs; but on the other hand, if too much foul Ore is left in it, that will alfo be to the prejudice of the concerned. Every ton of wafte Ore cofts as much to be fmelted as a ton of clean; at leaft, the buyer fubftracts as much for a ton of the one, as the other.

Suppofe

Suppoſe the buyer allows three pounds ſterling for his charges of ſmelting and working a ton of Ore, and conſequently the ſame ſum for each ton of waſte in the Ore, which in reality the ſmelting coſts the buyer or refiner; and therefore he muſt deduct ſo much from the produce of the Ore ⅌ ton. This is the caſe in Cornwall; but in other places, more diſtant from the furnaces, in Ireland for inſtance, the deduction muſt amount to more money, in proportion to the duty there on Ore, and alſo an overplus of freight, and if there be any other ſurpluſage of coſt, more than in Cornwall, as a longer carriage by land, and the like, all will operate to leſſen the value of the Ore: but where ſuch incidents are leſs than common, as a very ſhort freight, or little charge in land carriage, then inſtead of a deduction, there is room to make a further advance of the price.

To illuſtrate this caſe, ſuppoſe one hundred tons of Copper Ore, to be worth ten pounds ⅌ ton, the amount of which will be one thouſand pounds; ſuppoſe alſo it has ſo much earth or waſte in it, that it may be reduced to fifty tons, with a moderate charge in dreſſing, and with an inconſiderable loſs of the Ore; then each ton will contain nearly the Copper which two tons did before: and whereas the buyer would have taken out ſix pounds for the charges of carriage, freight, and ſmelting of two tons, he will now deduct but three pounds for thoſe charges upon the ſame Ore in one ton: ſo that inſtead of deducting three hundred pounds on the one hundred tons of Ore, he will now deduct but one hundred and fifty pounds on fifty tons, whereby the adventurers will ſave ſo much of the other one hundred and fifty pounds, by how much the parcel of Ore will coſt leſs for dreſſing and taking out the waſte; for the fifty tons of Ore will now be worth twenty-three pounds ⅌ ton, which will amount to eleven hundred and fifty pounds inſtead of one thouſand. Yet if the Ore be light or rich, there may be more of it loſt, than the uſeleſs waſte carried off may compenſate.

Again, if one hundred tons of waſte were mixed with the one hundred tons of Ore worth ten pounds ⅌ ton, then the buyer would make an additional abatement of three hundred pounds more for his charges upon the one hundred tons of waſte; ſo that the whole amount of the Ore, would be but ſeven hundred pounds, inſtead of one thouſand pounds; for the Ore would be only worth three pounds ten ſhillings ⅌ ton; according to which, it is plain, that Ore may be too curiouſly or too careleſſly dreſſed. For Ore rich in nature, may be brought to

a great

a great rate, and produce a large profit to the adventurers; otherwiſe it may be ſold to a great diſadvantage, and without any gain, for want of being well handled: there are, however, ſeveral poor Ores, ſo dry and barren by nature, that they are not capable of being ſo well conditioned, as to bring a good price.

The concluſion I would draw from hence, is, that if a ton of waſte can be taken out of the Ore, for leſs than the charge of ſmelting a ton (which I call three pounds here) and without any conſiderable loſs of Ore, the adventurers ſave money by dreſſing it thus: but if the charges of taking out a ton of waſte ariſe to more than three pounds, then they loſe as much as the exceſs of coſt amounts to, together with the Ore waſhed away; hence, mediocrity ſhould always be obſerved.

The dreſſers of Copper Ore often work for monthly wages, but then they do not always make the diſpatch they ought; therefore they more commonly agree with the adventurers at a certain or fixed price for every ton of dreſſed Ore; but this makes it the dreſſers intereſt, to make the greateſt number of tons that he can, ſo that the adventurers may ſuffer a loſs, for want of a true cleanſing the Ore. To prevent this inconvenience, the beſt method is to ſet the Ore to dreſs in proportion to the price it brings ℔ ton; or in other words, to allow the dreſſer ſo much in the pound ſterling, according to the price the Ore will bring; for this makes it his intereſt, as well as the adventurers, to make the Ore as merchantable as he poſſibly can: however, he ſhould be ſtinted from throwing away too much Ore in the halvans, or be obliged to ſtamp the halvans, and return their contents in Ore.

There can be no ſtated rule given for ſetting Ores to dreſs at a price, becauſe the Ore is incompact, or leſs, as well as poorer in value, in ſome Mines, more than in others; but where Ore riſes with little waſte, it may be dreſſed at a much cheaper rate, eſpecially if it be rich in quality. I have known Copper Ore in ſeveral Mines, where it might be ſifted out at the Shaft ſide, without any other trouble, to be dreſſed for one penny in the pound ſterling; on the other hand, five ſhillings may not be a ſufficient price for Ore that is hard and barren.

It may be worth enquiry, whether very ſulphureous Ores which abound with Mundick, may not be advanced in value by

backwardneſs of the Copper companies, by erecting more furnaces, and running the ſame Regule into fine Copper; a circumſtance of great notoriety, which might be followed by many good conſequences for them and their neighbourhood.

Lead Ore, like that of Copper, as it comes out of the Mine, is very little of it merchantable, or fit for ſale or ſmelting; the foſſils and ſoil mixed with it, muſt firſt be ſeparated by breaking and waſhing, according to the nature, richneſs, or poverty of the Ore.

As for Lead Ore that does not riſe very ſolid, it ought to be bucked and jigged, and very ſeldom carried to the ſtrêke, or ſtamps, except it be very ſcarce and thin in the ſtone; but when it is ſo poor as to make bucking and jigging improper and coſtly, then it is ſcarce worth the trouble of ſtamping and dreſſing: however, when it is ſo treated, the grate of the ſtamping-mill ſhould be yet coarſer than for Copper Ore; becauſe Lead Ore breaks into Facets or flakes, and is thence liable to float away and be loſt, even with a very eaſy ſtream of water. The method of jigging has been uſed a long time in the Lead Mines in Cornwall, though but very lately in the Copper Mines, and they find it to turn to good account both in the one and the other. There can be no doubt, that the Corniſh were almoſt entirely obliged to the Derbyſhire and other Lead Miners, for the beſt method of dreſſing Copper Ores in the firſt place; which I ſuggeſt from the antiquity of Lead Mines in the northern counties, and the much later diſcovery of Copper Ore in Cornwall: to which we muſt add, that the great ſimilarity in the nature and gravity of Copper and Lead Ores, would naturally incline us to uſe one and the ſame method for their purification. Nevertheleſs, it muſt be allowed, that the great varieties of Copper Ores in Cornwall, ſome of which require a very nice management in dreſſing, have given her Miners a preeminent judgment in that matter, which is warranted by continual obſervation and experience.

But when Lead Ore riſes rich, in large ſolid pieces, it is broke with a hammer into cubes, from half an inch to one inch of a ſide; and this is called Bing in Derbyſhire, but in Cornwall it is ſtiled Cobbed Ore. Such part of the Ore which is too impure for bing, is further beaten down with a broad headed hammer called a Bucker, according to its degree of mixture with foſſils, &c. which this beating is intended to break off, and

and prepare for ſeparation in water. This, with what was neceſſarily broken to an under-ſize in making bing, they term Knock-bark, i. e. Bucked Ore; which being put into a wire ſieve, and waſhed in a kieve or vat filled with water, the Ore preponderates in the ſieve according to its ſpecifick gravity. Thus the ſmaller parts of the Ore go through the meſhes of the ſieve into the vat, the larger parts reſt on the bottom of the ſieve, and the foſſil part forms a ſtratum above the Ore, which is taken off with a ſemi-circular flat board or hand ſhovel called a Limp, and is thrown away; and the Ore remaining in the ſieve, thus ſeparated, is called Peaſy. Thoſe particles which paſſed through the meſhes of the ſieve, in ſeparating the peaſy from the foſſils, with all ſuch ſmall particles of Ore as have been pulverized in getting or dreſſing, together with thoſe in the waſte hillocks, (halvans and henaways) is again waſhed over in the ſieve and vat, once, twice, or three times, in order to ſeparate and cleanſe the Ore, which they call Smitham. In this manner are formed the three aſſortments of Lead Ore, viz. Bing, Peaſy, and Smitham. Now in Cornwall theſe three ſorts are generally mixed together for ſale; before which, we call the Bing, Cobbed Ore; and the Peaſy and Smitham, Jigged Ore, the Peaſy being firſt Bucked. So much in general do the methods of dreſſing Copper and Lead Ores agree, that in the foregoing account they differ in nothing but terms of art.

There is another method of dreſſing very tender Copper and Lead Ores, ſpeedier than bucking, viz. in dry ſtamps, where the Ore has no water to carry it through a grate, but it is ſtamped dry or a little moiſtened. In dry ſtamping, it falls out of the mill, partly in groſs lumps; and one attends who with a ſhovel throws it on a proper ſized hurdle, through which the ſmaller pieces fall; and the larger that run down to the foot of the hurdle, being pounded ſmall enough to paſs through the hurdle likewiſe, the whole is dreſſed and cleanſed by jigging as before.

When the Ores of Copper or Lead are dreſſed and made ſaleable in Cornwall (for Lead Ore is diſpoſed of in a different manner in Derbyſhire, and the northern counties) the piles or heaps are either kept ſeparate for a market, if the quantities are large; or elſe the different ſorts are well mixed together in one pile, very rarely exceeding one hundred and eighty or two hundred tons in one parcel, and from thence, down to one hundred, eighty, ſixty, fifty, forty, twenty, ten, five, or even one

one ton, if the ſeller pleaſes, which is ſeldom the caſe, and never for his advantage. If a Mine has four hundred tons of Copper Ore dreſſed ready for ſampling, the managers may divide one half of the quantity, for inſtance, in two parcels of one hundred tons each, and the other two hundred tons thus; one parcel of eighty, another of fifty, another of forty-two, another of twenty-one, and the laſt may be a ſmall parcel of poor ſtamped Ore computed ſeven tons, in all, four hundred. But the reader is not to underſtand, that theſe different parcels were ever mixed with each other: they may belong to ſeparate takers upon tribute each parcel, they may lie at ſeveral diſtances from each other, and be of very unequal value; for the firſt hundred tons may ſell for four pounds ℔ ton, the next for five pounds ten ſhillings, the eighty for fifteen pounds ℔ ton, the fifty for eight pounds five ſhillings, and ſo on of all the reſt. It is very common, however, for tributors to mix their Ores with the owners, or with each other of their fellow tributors, ſo that the Ores of four or five different ſets of people may be all mixed together to make one ſample for conveniency of ſale, purſuant to the directions of the managers or captains of the Mine, previous to which, their ſeparate parcels muſt be nicely weighed and private ſamples taken: but I have illuſtrated this matter in book iii. chap. iv.

A dreſſed parcel of Ore, before the day of ſampling, is very well mixed by ſeveral men, who turn it over again and again, a perſon ſtanding on the top of the pile or parcel, who ſpreads every ſhovelful circularly, and as equally as he poſſibly can, ſo that in fact, it is mixed with great exactneſs. This parcel, if leſs than ten tons, is divided into three Doles or piles; if above ten, into four Doles; and if ever ſo many more than nineteen tons, it is divided into ſix Doles; and then it is ultimately ready to be ſampled.

Now when the ſamplers meet upon the ſpot according to appointment, either of them, indifferently, fixes upon the one-ſixth, one-fourth, or one-third Dole of a parcel according as it is great or ſmall, to take their ſamples from. The Miners then cut or part that Dole athwart and acroſs down to the ground, ſo that is divided nearly into quarters, by theſe tranſverſe channels which are cut through it. Then a ſampler with a ſhovel pares down a little of the Ore from all parts of the channels, to take as equal and regular a ſample throughout the whole, as he can, to the amount of two or three hundred weight,

BOOK V.

CHAP. I.

On the Art of Aſſaying Ores and Minerals; deſcribing the Utenſils and Fluxes for Aſſaying.

IT is not here propoſed, to teach the art of aſſaying Ores, ſo as to determine the quantities of Metal they contain with ſuch accuracy, as is neceſſary for thoſe who buy Copper or Tin Ores, that being a peculiar trade: nothing but inſtruction by a good aſſayer, and much practice in the buſineſs, can make a man a perfect adept in the art. What is intended here, is, only to give the principles of aſſaying, with ſuch an idea of the practice as may help a perſon to attain that degree of proficience which will enable him to form a pretty good judgment of Mineral ſubjects in regard to their contents. And if a man hath a genius for ſuch ſort of enquiries, with that degree of diligence and attention which uſually accompanies it, it is poſſible that what is here ſaid, may open the way for a more ſcientifick and extenſive knowledge and practice of aſſaying, than is at preſent known or uſed in the county of Cornwall; for whoſe uſe this little eſſay is chiefly calculated and recommended.

To the forming a comprehenſive idea of Ores, &c. a man ought to know the natural hiſtory of thoſe things which enter into their compoſition, which are the Metals, as Gold, Silver, &c. and the Semi-metals, Biſmuth, Cobalt, Antimony, &c. Brimſtone is alſo a very common and almoſt a conſtant concomitant of the Metals and Semi-metals in Ores, as well as ſtones or earths, which in Cornwall are almoſt always of the vitrifiable kind, that is, ſuch as run into glaſs with fluxing materials; as the fixed ſalt of vegetables, pearl aſhes, and ſalt of tartar; nitre, diveſted of its acid by means of any inflammable matter; borax, and the calxes of Lead; fluors, or the fuſile ſpars; clays, and ſtones, of the vitrifiable or flinty kind. By reference to book i. chap. iii. of this work, the reader will there find the natural hiſtory of

falls; wash this as the former precipitate, melt it with black flux, and it will be revived into Copper. The solution should be kept in hot sand, or water, during the whole time of the precipitation.

In the above process, the spirit of nitre being the proper solvent of Silver, Copper, Lead, and Bismuth, if any of these matters are in the Ore they are dissolved; that is, after the sulphur is burnt off, which would otherwise guard them from being attacked by the spirit. It is expedient, that there should be a larger quantity of spirit than is just necessary to dissolve the Metals, otherwise they might precipitate one another; it is therefore right, to taste the solution; and if it tastes very sharp and acrid, the quantity of spirit hath been sufficient. To make this experiment as accurate as possible, in regard to quantity, the calx ought to be finely levigated in a glass mortar; and the affusion of spirit of nitre, and the digestion, &c. continued as often, and as long, as any thing metallick can be gotten from the calx.

Process II. To assay Pyrites, Marcasites, or Mundicks, for Gold or Silver.

Light a fire in the wind furnace, with common coal; and when it is got up to a good white heat, place a crucible in it, which should be first dipped in water to prevent its cracking; surround it with coal almost to the brim, and as soon as it is of a good strong heat inclining to whiteness, put into it the Mundick designed to be assayed, which ought to be previously weighed. Shut the opening of the furnace with the bricks used for that purpose. Let it remain till it is perfectly fused; then pour it into a cone, greased; or rather smoked by the flame of a candle; when it is cold, knock it out of the cone, and separate the reguline or metallick part from the scoria, if any on the surface of it. A cone is a hollow vessel made of cast Iron. See fig. 2, plate VI.

Process III. The method of scorifying this Mundick, or converting all the parts which compose it (except the noble Metals) into Glass.

Place a crucible of the largest size, on a piece of brick suitable to it, in the middle of the wind furnace. Make a fire round it with charcoal till it is red hot, when common pit-coal

may

may be uſed. Then put in the Regulus of the Pyrites or Mundick, with one half its weight of Lead revived from litharge, and as much Glaſs of any kind, with as much litharge as Glaſs, previouſly mixed together. Raiſe the fire till all is melted, and the ſulphur and arſenick appear to riſe through the Glaſs a-top, and fly off in a flame. Continue the fire for ſome hours, till this appearance ceaſes, and the Glaſs melts ſmooth like oil, when it may be ſuppoſed the ſulphur and arſenick are conſumed and the ſcorification pretty far advanced. In this part of the operation, it will be neceſſary, from time to time, to make freſh additions of litharge to thin the Glaſs, which is apt to grow thick and tenacious by the Iron (which is continually ſcorifying) mixing with it. When the litharge is thrown in, it ought to be mixed up with the Glaſs a-top, by means of an Iron rod. The Glaſs ought to be very thin before the whole is poured out; when this is the caſe, pour it out into the greaſed or ſmoked cone; and when cool, knock it out, and ſeparate the ſcoria from the Lead at bottom. If the Lead is quite ſoft and malleable, and the ſcoria very thin, ſo that if a wire was dipped in them, they would have dropped off it like oil, leaving only a varniſhed like appearance on the wire; the operation is well done: but if the Metal is brittle and hard, the operation muſt be continued till it is rendered quite ſoft and malleable. Sometimes it is neceſſary to make an addition of freſh Glaſs, in order to a complete vitrification of the Iron, but then litharge muſt be added at the ſame time.

When the Lead is reduced to perfect ſoftneſs, it is fit for cuppellation. To carry this proceſs to perfection, it is neceſſary to bring the ſcoria to a complete vitrification, when they will be very thin and ſhining. They are then to be powdered, and mixed with their weight of black flux, a little powdered charcoal, and one quarter their weight of ſea ſalt decriptated: the whole is to be perfectly fuſed, till it flows like oil, when it is to be poured into the cone; and, when cold, the Lead in the bottom, which is like to be in conſiderable quantity, muſt be alſo cuppellated, but ſeparately from the other, in order to determine if the firſt aſſay was perfect or not.

The intention of the above proceſs, is to ſeparate the ſulphur and the arſenick from the Mundick; and to convert the Iron, which makes up a great part of this compound, into ſcoria; and finally to vitrify it ſo, that the Gold and Silver it may contain ſhall be abſorbed by and left in the Lead; which I think is perfectly

perfectly well done by this process. The sulphur and arsenick, are continually flying off through the Glass, which is likely to detain any of the nobler Metals, which the arsenick might otherwise volatilize; at the same time, the Iron which was mineralized by them, burns to scoria, and rising a-top of the metallick part mixes with the Glass, and is vitrified with it; the Mundick at bottom grows more and more metallick, and, as I apprehend, the Lead, if not entirely, is at least greatly mineralized by the sulphur and arsenick. The Iron and Lead, in this Mineral state, are mixed; but the Iron parting from these matters easier, as well as attracting them stronger, than the Lead, discharges them up through the Glass, and is gradually turned into scoria, till the whole of it is separated from the Lead, leaving with it the nobler Metals it contained.

The only hazard of missing in this process, is from the vessels being corroded by the Glass of Lead, which is very penetrating, when brought to that thinness by the litharge which is necessary; but this may be effectually prevented by the use of a porcelain or china-ware crucible, which as it is a new invention, and may be of great use to the curious in Metallurgy, without remarking on what others have done, I shall here give it to the publick in few words.

Process IV. Whoever hath been conversant in Mineral chymistry, must know, that vessels which will hold Glass of Lead, prove a great desideratum. Now the micose clay, which is one part of china ware, is known to be absolutely unvitriable; for though mixed with an equal part of vitriable stone, it stands the greatest heat that art knows, without being vitrified.* I believe all the grouan clays would answer to make the vessels in question; and, I know that the porcelain clay at St. Stephen's will. The composition I would recommend, is two parts of the washed clay, and one part of the gravel it contains, ground to a very fine powder, mixed and made into a paste. Let a potter form them into the shape of coffee dishes of a moderate thickness, and of different sizes, according to the purposes they are designed for. They must be burned in a crucible, or with crucibles, or porcelain, if you are in the neighbourhood of a factory of either kind. The fire must be full as strong as is necessary to burn china ware or crucibles; but if one hath not the advantage of a neighbouring pottery, the highest heat that

* See book i. chap. iii. upon Steatitæ, or Soap-rock.

can be given in a ſmart wind furnace, is ſufficient. When burned, they are a true unglazed porcelain as it is poſſible; the St. Stephen's clay without mixture, may make the ſtrongeſt veſſels; it might be tried: but I know common porcelains anſwer extremely well.

As theſe veſſels will by no means bear an open fire, they muſt be guarded: the beſt way of doing which, is to place them in crucibles made round, and about two-thirds of an inch, or an inch wider. Lay in the bottom of the large crucible the thickneſs of half an inch of flint ſand; if this cannot be had, Quartz, or (as it is improperly called in Cornwall) Spar, may be powdered and ſifted through a hair ſieve: fill up the vacancy between the two crucibles with the ſand or powder, and let the outſide crucible have a cover made to it exactly like that of a teapot, and the apparatus is finiſhed. See plate VI, fig. 3. This apparatus muſt be fixed on a conical baſe made of two parts pipe clay, and one part ſand; the ſhape of it is to be ſeen plate VI, fig. 4, a little excavated at top, to let in the crucible that it may ſtand ſteady.

I have thought proper to give this proceſs on Pyrites, as there has been much contention about the matter; people will now have it in their power to know whether or not they are of any value.

Any Ore that is ſuppoſed to contain Silver, or Gold, mixed with a proper quantity of litharge, with revived Lead at bottom, and a mixture of Glaſs, if the Ore has no vitrifiable ſtone in it, may be tried the ſame way. The want of vitrifiable ſtone or earth, may be known by the ſcoria, which will be tough and metallick, not glaſſy.

Litharge is eaſily revived, by mixing it with a proper quantity of black flux, and a little charcoal duſt, and melting the whole in a ſtrong fire, till the ſurface melts ſmooth and equal, without bubbling.

Proceſs V. Cuppellation; and the ſeparation of Silver and Gold by Aqua Fortis.

The veſſels uſed in this proceſs, are called Cuppels, and are formed ordinarily of bones burned white and powdered, or of the aſhes of vegetables from which the ſalts have been thoroughly

 ſeparated

the ſpirit of nitre, and the pot-aſh; the vegetable alkali being the baſis of nitre.

Proceſs VII. Proof Aqua Fortis.

Take any quantity of good aqua fortis, which will diſſolve Silver; drop into it a few drops of a ſaturated ſolution of Silver: if there appears to be any precipitate or cloud of a white colour, as there will if the aqua fortis has ſpirit of ſalt in it, which I believe is always the caſe; if this precipitate falls ſoon to the bottom, it is proof the aqua fortis contains much ſpirit of ſalt, and one may be bolder in dropping in the ſolution of Silver; but if it is thin and light, it is neceſſary to proceed with more caution. Let this milkineſs ſettle; and to a ſmall quantity of the aqua fortis in a phial, add a drop of the ſolution of Silver; and if there ſtill appears a milkineſs, more of the ſolution may dropped in, always aiming to add no more of the Silver ſolution, than is neceſſary to ſeparate the whole of the ſpirit of ſalt from the aqua fortis, which may be known by adding a drop of the ſolution to a little of the aqua fortis in a phial; for if the aqua fortis is proof, it will continue quite clear without the leaſt milkineſs.

There is an eaſier way of preparing proof aqua fortis, which is by putting a bit of Silver into it, and ſhaking it ſeveral times in a few hours; and if, the next morning, it is ſettled quite clear, and any of the Silver is left, it is proof. The only queſtion is, whether it doth not contain Silver; to determine this, drop a few drops of it into filtered brine, and if there ariſes no cloudineſs in the mixture, the aqua fortis contains no Silver.

Spirit of ſalt will not diſſolve Silver; but being diſſolved in aqua fortis, there is a ſtronger attraction between the ſpirit of ſalt and the diſſolved Silver, than between it and the aqua fortis, as it diſlodges the ſpiritus nitri, and unites with the Silver into a ſalt that is not diſſolvable in water, and ſo ſinks to the bottom in a white curd called Luna Cornea, which may be reduced into Silver with pot-aſh, by being melted with it; and if the pot-aſh is not in too great a quantity, it will be converted into a ſea ſalt, with a vegetable alkali baſis; by which it appears, that the ſea ſalt was decompoſed, or ſeparated from its mineral alkaline baſis, in the operation of precipitating the Silver. What is called the Mineral Alkali, or Baſis of Sea Salt, is of the

 ſame

into a compound crocus metallorum, confifting of the calcined Antimony and Tin. The Silver not being calcinable, when the fulphur which mineralized it is feparated by the nitre, it regains its metallick form, and falls to the bottom of the cone.

The compound crocus metallorum, and the amber fcoria, may be reduced into a metallick form, by being mixed with a proper quantity of black flux, and melted in a crucible; but not without great lofs of the regule. This procefs for the feparating Gold from Tin by Antimony, may be applied to Copper, or any other Metal.

Procefs X. To affay Copper Ore.

Powder the Ore and fift it through a hair fieve; fhake and mix it together, that every part of the powder may be alike, in regard to its metallick contents: form this powder on a piece of paper into a bed of half an inch thick; then weigh off a troy ounce, or ounce and quarter of it, from different parts of the bed or heap: and in order to affay it, the Ore is firft to be calcined, in the following manner:

The wind furnace having been before well heated, is to be filled with fea coal, reduced to the ftate of charcoal, or as it is ufually called, coakt or charkt. A crucible of the largeft fize for affaying, is then placed in the furnace, fo that the top of it fhall be a little beneath the top of the furnace. It is very proper to place one layer, or a few pieces of raw coal, round the top of the crucible, to keep down the flame and heat, which would otherwife incommode the operator in the calcination. The Ore may now be put into the crucible, and fome of the covering bricks put on the mouth of the furnace to raife the fire; but this muft be done gently. As foon as the Ore is obferved to be of a dufky red, it is time to begin to ftir it, to prevent its melting and running into lumps, which muft by all means be prevented, both by ftirring, and a proper regulation of the fire. The Iron rod ufed in ftirring, fhould be about two feet and a half long, and as thick as the end of the little finger, the one extremity of it flattened and formed like the toes of a pair of tongs, fo as to fuit the bottom of the crucible. With this rod the Ore is to be ftirred brifkly from time to time, fo as to prevent its melting, or running into lumps; and if it fhould appear difpofed to do this, it muft be ftirred very brifkly, till the appearance ceafes, and the Ore is again reduced into a powdery

form.

form. It will not be neceſſary to ſtir the Ore continually; but when you ceaſe to ſtir, the rod muſt not be taken out of the crucible but left in it, the upper end reſting on the bricks of the chimney.

In the beginning of the calcination, a large quantity of ſulphureous and arſenical fumes will be diſcharged from the Ore; and moſt Ores, at this time, emit alſo more or leſs of a ſulphureous flame. As the Ore parts with theſe volatile matters, it grows leſs fuſible, ſo that the fire may be ſuffered to encreaſe a little, in proportion as the Ore is leſs liable to melt. The operation muſt be thus continued, till the Ore emits no longer any viſible fumes. When the crucible is taken out of the fire and ſmelt at, if it yields no ſmell of ſulphur, even when it hath been expoſed to a ſtrong red heat, a little inclining to white, then it is ſufficiently calcined. This proceſs generally takes three quarters of an hour, and the fire muſt be often renewed by adding freſh charks, and raw coal.

In this proceſs, the Ore is freed from the ſulphur and arſenick which mineralized it, and is now reduced to the Metals and ſtony ſubſtances; but as the Metals cannot be collected by fuſion into a body, as the ſtony parts are infuſible, this makes it neceſſary to uſe ſuch things as will turn theſe ſtony matters into Glaſs, by the following proceſs of Scorification.

Proceſs XI. Suppoſing the quantity of Copper Ore made uſe of, to be one ounce, mix with it one ounce and a quarter, good weight, of black flux, and half a thimble full of powdered culm; put theſe into the crucible the Ore was calcined in, and cover them with nearly half an ounce of ſea ſalt. Fill the furnace with charks, and place the crucible in the furnace, ſurrounding it with charks to the brim. After you have covered it with a cover, made of the ſame compoſition with the crucible, put on the covering bricks on the mouth of the furnace, when the fire will riſe, and the matters in the crucible will be heard to melt and boil. When theſe appearances have ceaſed for ſome time, remove the bricks, and inſpect the matters in the crucible; if the ſurface is agitated, and the boiling and fermentation continue, the ſcorification is not complete. If the fire wants mending, mend it; place the crucible ſecurely, cloſe the furnace, and continue the fire, till the contents of the crucible flow like oil. Take it out of the furnace, and ſuffer it to cool; when cold, break the crucible, and ſeparate the Metal at bottom,

 from

to a calx, only it does it ſlower: the Iron, Tin, and Lead, calcining quicker than Copper, the effect of fire in refining is very evident. Nevertheleſs, the ſucceſsful management of it, can only be attained by attention and experience.

In Copper aſſays, the cone is not uſed, but an ingot of a peculiar kind. Hollows of a ſpheroidal form, are made in a piece of Iron or Steel about an inch thick. Theſe excavations are poliſhed very ſmooth, and the utenſil hath a handle formed out of it, ſee fig. 7, plate VI. The hollows contain about half an ounce of water, and are nearly an inch and quarter diameter. Some ſmoke theſe hollows with the flame of a candle, and others rub them with greaſe, or a rag incloſing ſome tallow, roſin, or wax.

Proceſs XIV. To aſſay Copper Ore the regule way.

Pulverize, ſift, and mix the Copper Ore, as in the tenth proceſs; then take the the ſame quantity of Ore, with an equal part of common powdered black glaſs, about a fourth or a fifth part of nitre, and half as much borax: mix and put them all together in the crucible, covered with one quarter of an inch thick of common ſalt. Melt theſe in the ſtrongeſt fire you can raiſe in the wind furnace till they flow freely, which will take ſome time longer than a ſample of calcined Ore. When cool, break the crucible, ſeparate the regulus from the ſcoria, pulverize it, and then proceed exactly in the ſame manner as with a calcinable Ore, ut ſupra.

Now, in order to calculate the value of a ton of Copper Ore by the produce of an aſſayed troy ounce, you are to remember, that if one ounce of Ore makes one pennyweight of fine Copper, it will be one part in twenty, five pennyweights will be five parts in twenty, and ſo on: therefore, a perſon who is familiar in the buſineſs, may know the value of a ton of Copper Ore off hand, by only aſking, how many parts in twenty ſuch a ſample has produced. But this valuation of an aſſay depends entirely upon a given ſtandard price for the ton of fine Copper, be it either ninety, ninety-ſix, one hundred, or one hundred and five pounds ſterling. Of courſe, every pound or twenty ſhillings that the ſtandard riſes or falls, will make a difference in the aſſay of one ſhilling or a twentieth in every pennyweight, and a halfpenny in every grain: as for inſtance, one pennyweight, one grain, at ninety-five the ſtandard, will make the produce equal

equal to four pounds fifteen ſhillings the pennyweight, and three ſhillings and eleven pence halfpenny the grain; but if the ſtandard is ninety-ſix, the produce muſt be valued at four pounds ſixteen ſhillings the pennyweight, and four ſhillings the grain. Three pennyweights and three grains at ninety-five the ſtandard, will amount to ſixteen pounds ſixteen ſhillings and tenpence halfpenny, and at ninety-ſix will riſe to ſeventeen pounds.

This mode of calculation being apprehended by the reader, I will proceed to a few examples by the rule of practice, which will ſet the matter in ſo clear and eaſy a light, that any perſon may calculate an aſſay of Copper Ore without the leaſt difficulty.

Suppoſe one troy ounce of Copper Ore produces an aſſay of fine Copper that weighs — at ninety pounds the ſtandard value of one ton of fine Copper, I firſt multiply the three pennyweights by four pounds ten ſhillings the ſtandard; for ten times three ſhillings are thirty ſhillings, and four times three pounds are twelve pounds, and with the twenty ſhillings from the place of ſhillings make one pound more, equal to thirteen pounds ten ſhillings: ſo that three pennyweights of fine Copper at ninety, is worth thirteen pounds ten ſhillings the ton: but here are nineteen grains unaccounted for in that price; therefore, I ſay, twelve grains are one half of a pennyweight, equal to two pounds five ſhillings; ſix grains, the half of that, are equal to one pound two ſhillings and ſixpence: and the one grain remaining, is equal to ninety halfpennies; for, as I have ſaid before, one grain is valued at ſo many halfpennies, as the ſtandard is pounds; therefore one grain is equal to three ſhillings and ninepence. By adding the whole together; I find the aſſay of three pennyweights nineteen grains, at ninety, is worth ſeventeen pounds one ſhilling and threepence ℔ ton of Copper Ore. Theſe are the groſs proceeds; but as there is an expence upon the bringing this ton of Ore into fine Copper, ſuch as carriage of the Ore to the coal by land or ſea, or both, furnaces, labour, coal to ſmelt it, &c. it muſt be deducted before we can fix the nett value thereof. Theſe returning charges are commonly rated at three pounds ℔ ton one with another; ſo that, of conſequence,

	Dwts.		Gr.
	3		19
	£4	10	
	£13	10	
	2	5	
	1	2	6
		3	9
	£17	1	3
	3		
	£14	1	3

one hundred tons of Copper Ore will require three hundred pounds expence to bring them into fine Copper; and the above ſeventeen pounds one ſhilling and threepence will be reduced to a nett value of fourteen pounds one ſhilling and ſixpence; it being cuſtomary to reckon no pence below ſix.

Nevertheleſs, in ſome Ores, theſe returning charges at three pounds are over much; for if it requires but that money to ſmelt Ore of fifty ſhillings nett value ℘ ton, it certainly cannot take the ſame to ſmelt Ore of thirty or forty pounds; as many of our rich gray Ores (which are naturally regulized) and native Copper demand but two or three flowings to be thoroughly refined. All theſe things are properly judged and conſidered by the purchaſers, who may add or diminiſh their eſtimates of returning charges as they chuſe, the ſeller being generally as ignorant of the whole as any perſon unconcerned in the affair. I ſhall ſubjoin two or three aſſays at different ſtandards, which may be calculated by the foregoing rule; premiſing, that if the reader would know the quantity of Copper Metal in one ton, or any given number of tons of Copper Ore, he muſt divide four hundred and eighty by the produce of the aſſay, and the remainder by twenty, and that will ſhew what quantity of Ore will make a ton of fine Copper.

	Dwt.	Gr.		
An aſſay of fine Copper weighs	1	19		at 95 the ſtandard.
	£4	15		
	2	7	6	
	1	3	9	
		3	11½	
	£8	10	2½	
Deduct for returning charges	£3			ſuch as ſmelting, &c.
Nett value	£5	10	6	℘ ton.

	Dwts.	Gr.	
An assay of fine Copper weighs	4	13	at 96 the standard.
	£4	16	
	£16		
	2		
	1	4	
	2	8	
		4	
	£21	16	
Deduct for returning charges	£3		
Nett value	£18	16	℘ ton.

	Dwts.	Gr.		
An assay of fine Copper weighs	2	7		at 100 the standard.
	£5			
	£10			
	1	5		
		4	2	
	£11	9	2	
Deduct	3			
Nett value	£8	9	6	℘ ton.

Process XV. To assay Lead.

If this Ore is pure, that is, free from Mundick or the like, the process is very easy. With an ounce of the powdered Ore mix about eight or nine pennyweights of fresh Iron filings. Melt the whole together in a pretty strong fire till it flows perfectly thin; then pour it into a greased cone or ingot; and, when cold, separate it from the scoria at top. If the separation should be difficult, put the whole into an Iron ladle, and when the ladle is red hot, the Lead will melt, and run from the scoria, and will pour out perfectly fine Metal.

As through the violence of the heat in the first melting, the Lead will take into it some of the Iron used in fluxing it; it is therefore

therefore neceſſary to remelt it in an Iron ladle, when the Iron will immediately riſe at top, in form of ſcoria, when the Lead may be eaſily poured off, and the ſcoria will be left in the ladle. A little tallow may be added before the Lead is poured off, which will reduce ſome of the Lead that was burned, and increaſe the produce.

In this operation, the Iron having a ſtronger attraction to ſulphur than Lead, frees the Lead from it, which by this means is reduced to its metallick form. The Iron is alſo mineralized by the Lead, which is evident, by its melting the Mundick ſhine, which thoſe ſcoria exhibit when broke; but eſpecially by falling abroad when expoſed to the air, and being convertible into copperas, juſt in the ſame manner as the ſulphureous Marcaſites are.

If Lead Ores have arſenical pyrites mixed with them, the aſſay is more difficult; for in this caſe, they muſt be calcined like Copper Ores, and all the arſenick muſt be evaporated. By adding powdered charcoal in proportion to one quarter the weight of the Ore, it will expedite the calcination, and prevent it from running into lumps, which it is very apt to do.

When it is calcined, it muſt be mixed with its own weight, or more, of black flux, and about a quarter or fifth part of Iron filings; put on them a layer of ſalt, and melt down, till it flows thin; then pour it out, and treat the Lead as was done in the former proceſs, to free it from the Iron.

The uſe of the calcination in this laſt proceſs, is to diſcharge the arſenick, which renders the Iron eaſily fuſible; and if the Ore was not calcined, would fall down, in a reguline form, together with the Lead, and render it impure. Beſides, it would cauſe an imperfect ſeparation of the ſcoria, and keep up a great deal of the Lead amongſt them; for, as this arſenical regulus would incorporate with the Lead, the mixture would be much lighter than Lead. The Iron filings are added, to abſorb the vitriolick acid that may be left in the Ore after calcination.

Lead is aſſayed for Silver or Gold on the cuppel, as directed before; and all the Silver it contains above twelve troy ounces in the ton, is profit.

Proceſs

Bismuth is easily separable from its Ore, and may be procured pure by melting the Ore in a crucible in a moderate fire, without any flux; but if it is very impure, an addition of the black flux will soon fuse it: however, the fire must not be too fierce, for if it be, the Bismuth will be lost.

To discover Silver in Gossans or very poor Ores.

Any Gossans or very poor Ores which are supposed to contain Silver, being calcined and mixed with three times their weight of litharge, may be assayed as directed in the process for assaying Mundick; only there will be no need of Glass, as the Ores are supposed to be stony. Care must be taken, that the scoria are thin at the last, either by the continuance of the fire (by which litharge will be formed from the Lead at bottom) or by the addition of litharge, as directed in the aforesaid process. The china-ware crucible is also best here.

CHAP. II.

Of Smelting of Copper Ores in the great Furnaces called Copper Works.

TO form a just and general idea of the construction of furnaces, and of the disposition of the several apertures in them, with a view to increase or diminish the activity of the fire, it will be proper to lay down, as our ground-work, certain principles of natural philosophy founded on experience.

First, Every one knows that combustible matters will not burn or consume unless they have a free communication with the air, insomuch that if they be deprived thereof, even when burning most rapidly, they will be extinguished at once; that, consequently, combustion is greatly promoted by the frequent accession of fresh air; and that a stream of air, directed so as to pass with impetuosity through burning fuel, excites the fire to the greatest possible activity.

Secondly, It is certain that the air which touches or comes near ignited bodies, is heated, rarefied, and rendered lighter than

than the air about it, that is further diſtant from the center of the heat, and conſequently that this air ſo heated and become lighter, is neceſſarily determined thereby to aſcend in order to make room for that which is leſs heated and not ſo light, which by its weight and elaſticity tends to occupy the place quitted by the other: another conſequence hereof is, that if fire be kindled in a place encloſed every where but above and below, a current of air will be formed in that place, running in a direction from the bottom to the top; ſo that if any light bodies be applied to the opening below, they will be carried up towards the fire; but, on the contrary, if they be held at the opening above, they will be impelled by a force which will drive them up, and carry them away from the fire.

Laſtly, It is a demonſtrated truth in hydraulicks, that the velocity of a given quantity of any fluid determined to flow in any direction whatever, is ſo much the greater the narrower the channel is to which that fluid is confined, and conſequently that the velocity of a fluid will be increaſed by making it run from a wider through a narrower paſſage. Theſe principles being eſtabliſhed, it is eaſy to apply them to the conſtruction of furnaces.

The materials fitteſt for building furnaces are, bricks joined together with potter's clay mixed with ſand, and moiſtened with water; potter's clay mixed with potſherds, moiſtened with water, and baked in a violent fire: alſo Stourbridge clay, and many of our tal'cy clays to be had in great plenty in the Corniſh ſoft grouan ſtrata, mixed and baked in the ſame manner.

The only kind of furnace for ſmelting Ores where bellows are not employed, is what is called a Reverberatory Furnace. The Germans call it a Wind Furnace. It is alſo diſtinguiſhed by the name of Engliſh Furnace, becauſe the invention of it is attributed to an Engliſh phyſician. The Copper furnaces bear four names, viz. the Calciner, which is the largeſt; the Operation, Roaſter, and Refiner, which are all of one gauge or nearly ſo both in ſhape and ſize.

The hearth or bed of the calciner ſhould be eighteen feet long and thirteen feet wide within, by two feet ten inches at a medium from its concave back to the bottom, which muſt be flat. The fire place three feet four inches long, by two feet wide and two feet deep, ſo as to have two feet of flame to paſs over

over the Ore in calcination. The length and breadth of the masonry of this furnace should be in proportion from out to out as they exprefs it, viz. twenty-four feet long, by eighteen wide.

Fig. 14, plate VI, reprefents a longitudinal fection of a reverberatory furnace ufed in the fmelting of Copper Ores: 1. the mafonry; 2. the afh-hole; 3. a channel for the evaporation of the moifture; 4. the grate; 5. the fire place; 6. the inner part of the furnace; 7. a bafon formed of fand; 8. the cavity where the melted Metal is; (that is, in the refinery, becaufe the Metal there is not tapped but laded out by an Iron ladle, therefore the bottom is concave, but thofe of the operation and roafter are flat) 9. a hole through which the fcoria are to be raked or removed; 10. the paffage for the flame and fmoke, or the lower part of the chimney which is to be carried up to a height of about thirty feet; 11. a hole in the roof, arch, or crown of the furnace, where the Ore is put in—This furnace is eighteen feet long, comprehending all the mafonry; twelve feet broad, and nine and a half feet high—The hearth or bottom is raifed three feet above the level of the foundery: on one fide is the fire place, under which is an afh-hole hollowed in the earth; on the other fide is a bafon made, which is kept covered with fire when there is occafion: on the anterior fide of this furnace there is a chimney, which receives the flame after it has paffed over the Ore that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of a clay capable of fuftaining the fire. This furnace has a hole in its front through which the fcoria are drawn out; and a bafon, as we have faid, on one fide, made with fand, in which are oblong traces for the reception of the regulus, matt, or black Copper, when the furnace is tapped.

The infide of this furnace is commonly an elliptick curve; becaufe it is demonftrated by mathematicians, that furfaces having that curvature reflect the rays of the fun, or of fire, in fuch a manner, that, meeting in a point or line, they produce there a violent heat. The moft advantageous fize of the melting area of this furnace is feven feet ten inches long, four feet eight inches broad, and two feet high at a medium. The fire place two feet eight inches long, by two feet wide, fo as to form one foot nine inches fire: the refining furnace has alfo two fide doors, one for raking or fkimming, the other for lading.

Fig. 15, plate VI. represents the upper plan of the furnace of which fig. 14 is a section: 1. the outer wall; 2. the draught-hole communicating with the ash-hole; 3. the door through which fossil coal is thrown into the fire place; 4. the place where an opening is made to let the melted Metal flow out of the furnace; 5. an opening through which the scoria are raked and drawn off; 6. the bason made of sand where the Metal lies; 7. the fire place with an Iron grate; 8. a small partition one brick thick between the fire place and the area of the furnace, over which the flame passes—This is called the Bridge.

Copper is generally mineralized, not only by sulphur and arsenick, but also by Semi-metals and pyritous matters, and is frequently mixed with other Metals. As this Metal has great affinity with sulphur and arsenick, it is almost impossible to disengage it from them entirely by roasting: hence in the smelting in great, nothing is obtained by the first operation but an impure Copper, which contains all the principles of the Ore, excepting the earthy and stony parts, particularly when the Ore is smelted crude and unroasted. However, the Copper Ore when brought to the works in some few places is refined by repeated smeltings and roastings without calcination: but as I propose to describe all the processes for its ultimate refinery, I shall begin with that of calcination, which in most places is nearly thus.

A certain quantity of the Ores, called a charge, from ten, to thirty, or forty hundred weight, is put into the calciner, where it is frequently stirred in such a heat as will not melt it, during a tide or twelve hours, more or less as the nature or mixture of the Ores require: two, three, four, or five hundred weight of this Ore is then put with five, four, three, or two hundred weight of raw Ore into an operation furnace. The fire is made very intense, and the whole becoming fluid and thin at the end of four hours the flag is skimmed or drawn off through the hole of the furnace no. 5, fig. 15, plate VI, by an Iron rake called a Rabble. Another like quantity of Ore is put in, and the same manœuvres being thrice repeated, the greater part of the remainder, being thus skimmed, in a state of fluidity, and under a great heat, is at the end of twelve hours let out by a tap-hole in the side of the furnace no. 4, fig. 15, plate VI, into a bed of sand where it forms itself into pegs or pigs, and is now a regulus. These pegs are taken before they are cold, and on Iron wheel barrows are conveyed and plunged into a trough or cistern

ciſtern of cold water. From thence the regulus is carried to a horſe mill, and there reduced almoſt to a powder. In ſome places this is done by women, girls, and boys, for the ſake of employing them, which they term bucking the regulus, and is performed the ſame as bucking deſcribed in our chapter upon dreſſing Copper Ores. In this condition it is carried to a furnace, called a Metal Calciner, where a quantity from fifteen to forty hundred weight (according to the capacity of the furnace) is ſpread over the bottom, and, by ſuch a fire as will not juſt melt it, again calcined for about two tides or twenty-four hours. From thence it is drawn out, cooled by water, and carried to the Metal furnace, where it is fuſed, ſkimmed, and tapped out at the end of twelve hours in pegs, much in the manner of the operation furnace before deſcribed. The roaſting furnace next takes this Metal (as the workmen call it, though it is very far from being in a ſtate of malleability) whole in the pegs, where they are roaſted ſixteen or eighteen hours, and when the fire is riſen, they are melted, ſkimmed, and tapped as before. This operation of roaſting and flowing, &c. is repeated three or four times; ſome Copper Metal evidently appearing in it, it is carried to the coarſe refining furnace, from whence when melted, ſkimmed, and ready for its exit, it is not tapped, but taken out in Iron ladles and thrown into oblong Iron pots or moulds by a ladle full at a time, each mould containing about one hundred and a half. A quantity of this fine Copper from ſixteen to twenty-five hundred weight according to the capacity of the furnace and uſage of the works, is put into the refiner, or refining furnace, where being again melted by an intenſe heat, ſkimmed, and otherwiſe rendered proper for the purpoſe, it is again laded out in ſuch ſhapes and quantities, as the maſter or director of the works requires, and may beſt ſuit the rolling mill, the battery mill, or the other demands of the manufacturers.

I ſhall make no mention of extracting the ſmall quantities of Copper and heterogeneous Metals which remain in the ſlags or ſcoria ſkimmed off in the ſeveral operations, which after extraction is often mixed with ſome others to make thoſe inferior Metals called Pot-metal, Manillions, &c. nor of the ſeveral kinds of fluxes which are few and differently uſed by different operators, neither can it be of ſervice to any but an adept in the buſineſs. My intention is only to give a general idea of the proceſſes in ſmelting as far as they have fallen under my obſervation, and not meddle with the private manufactory or œconomical

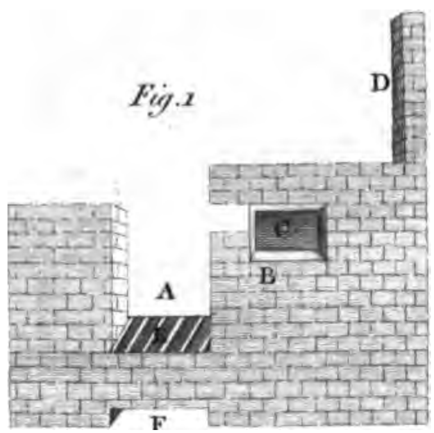


Fig. 1

Fig. 12

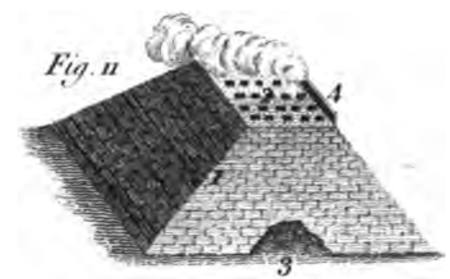


Fig. 11

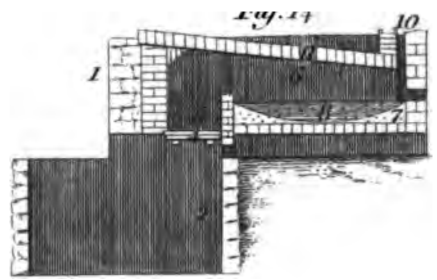
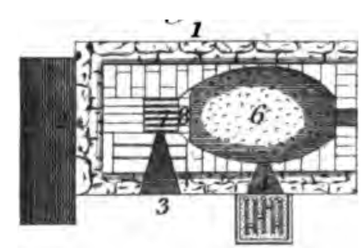


Fig. 14



At 12 for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
lb	lb	20	C.	C.	Q	lb	20
1	—	12	1	—	2	11	4
2	1	4	2	1	—	22	8
3	1	16	3	1	3	5	12
4	2	8	4	2	1	16	16
5	3	—	5	3	—	—	—
6	3	12	6	3	2	11	4
7	4	4	7	4	—	22	8
8	4	16	8	4	3	5	12
9	5	8	9	5	1	16	16
10	6	—	10	6	—	—	—
11	6	12	20	12	—	—	—
12	7	4	30	18	—	—	—
13	7	16	40	24	—	—	—
14	8	8	50	30	—	—	—
			60	36	—	—	—
28	16	16	70	42	—	—	—
56	33	12	80	48	—	—	—
84	50	8	90	54	—	—	—
			100	60	—	—	—
			200	120	—	—	—

At 12½ for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
lb	lb	20	C.	C.	Q	lb	20
1	—	12½	1	—	2	14	—
2	1	5	2	1	1	—	—
3	1	17½	3	1	3	14	—
4	2	10	4	2	2	—	—
5	3	2½	5	3	—	14	—
6	3	15	6	3	3	—	—
7	4	7½	7	4	1	14	—
8	5	—	8	5	—	—	—
9	5	12½	9	5	2	14	—
10	6	5	10	6	1	—	—
11	6	17½	20	12	2	—	—
12	7	10	30	18	3	—	—
13	8	2½	40	25	—	—	—
14	8	15	50	31	1	—	—
			60	37	2	—	—
28	17	10	70	43	3	—	—
56	35	—	80	50	—	—	—
84	52	10	90	56	1	—	—
			100	62	2	—	—
			200	125	—	—	—

At 12¼ for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
lb	lb	20	C.	C.	Q	lb	20
1	—	12¼	1	—	2	12	12
2	1	4½	2	1	—	25	4
3	1	16¾	3	1	3	9	16
4	2	9	4	2	1	22	8
5	3	1¼	5	3	—	7	—
6	3	13½	6	3	2	19	12
7	4	5¾	7	4	1	4	4
8	4	18	8	4	3	16	16
9	5	10¼	9	5	2	1	8
10	6	2½	10	6	—	14	—
11	6	14¾	20	12	1	—	—
12	7	7	30	18	1	14	—
13	7	19¼	40	24	2	—	—
14	8	11½	50	30	2	14	—
			60	36	3	—	—
28	17	3	70	42	3	14	—
56	34	6	80	49	—	—	—
84	51	9	90	55	—	14	—
			100	61	1	—	—
			200	122	2	—	—

At 12¾ for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
lb	lb	20	C.	C.	Q	lb	20
1	—	12¾	1	—	2	15	8
2	1	5½	2	1	1	2	16
3	1	18¼	3	1	3	18	4
4	2	11	4	2	2	5	12
5	3	3¾	5	3	—	21	—
6	3	16½	6	3	3	8	8
7	4	9¼	7	4	1	23	16
8	5	2	8	5	—	11	4
9	5	14¾	9	5	2	26	12
10	6	7½	10	6	1	14	—
11	7	¼	20	12	3	—	—
12	7	13	30	19	—	14	—
13	8	5¾	40	25	2	—	—
14	8	18½	50	31	3	14	—
			60	38	1	—	—
28	17	17	70	44	2	14	—
56	35	14	80	51	—	—	—
84	53	11	90	57	1	14	—
			100	63	3	—	—
			200	127	2	—	—

At 13 for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
℔	℔	20	C.	C.	Q	℔	20
1	—	13	1	—	2	16	16
2	1	6	2	1	1	5	12
3	1	19	3	1	3	22	8
4	2	12	4	2	2	11	4
5	3	5	5	3	1	—	—
6	3	18	6	3	3	16	8
7	4	11	7	4	2	5	12
8	5	4	8	5	—	22	8
9	5	17	9	5	3	11	4
10	6	10	10	6	2	—	—
11	7	3	20	13	—	—	—
12	7	16	30	19	2	—	—
13	8	9	40	26	—	—	—
14	9	2	50	32	2	—	—
			60	39	—	—	—
28	18	4	70	45	2	—	—
56	36	8	80	52	—	—	—
84	54	12	90	58	2	—	—
			100	65	—	—	—
			200	130	—	—	—

At 13½ for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
℔	℔	20	C.	C.	Q	℔	20
1	—	13½	1	—	2	19	12
2	1	7	2	1	1	11	4
3	2	½	3	2	—	2	16
4	2	14	4	2	2	22	8
5	3	7½	5	3	1	14	—
6	4	1	6	4	—	5	12
7	4	14½	7	4	2	25	4
8	5	8	8	5	1	16	16
9	6	1½	9	6	—	8	8
10	6	15	10	6	3	—	—
11	7	8½	20	13	2	—	—
12	8	2	30	20	1	—	—
13	8	15½	40	27	—	—	—
14	9	9	50	33	3	—	—
			60	40	2	—	—
28	18	18	70	47	1	—	—
56	37	16	80	54	—	—	—
84	56	14	90	60	3	—	—
			100	67	2	—	—
			200	135	—	—	—

At 13¼ for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
℔	℔	20	C.	C.	Q	℔	20
1	—	13¼	1	—	2	18	4
2	1	6½	2	1	1	8	8
3	1	19¾	3	1	3	26	12
4	2	13	4	2	2	16	16
5	3	6¼	5	3	1	7	—
6	3	19½	6	3	3	25	4
7	4	12¾	7	4	2	15	8
8	5	6	8	5	1	5	12
9	5	19¼	9	5	3	23	16
10	6	12½	10	6	2	14	—
11	7	5¾	20	13	1	—	—
12	7	19	30	19	3	14	—
13	8	12¼	40	26	2	—	—
14	9	5½	50	33	—	14	—
			60	39	3	—	—
28	18	11	70	46	1	14	—
56	37	2	80	53	—	—	—
84	55	13	90	59	2	14	—
			100	66	1	—	—
			200	132	2	—	—

At 13¾ for 20

Bl. Tin	White Tin		Bl. Tin	White Tin			
℔	℔	20	C.	C.	Q	℔	20
1	—	13¾	1	—	2	21	—
2	1	7½	2	1	1	14	—
3	2	1¼	3	2	—	7	—
4	2	15	4	2	3	—	—
5	3	8¾	5	3	1	21	—
6	4	2½	6	4	—	14	—
7	4	16¼	7	4	3	7	—
8	5	10	8	5	2	—	—
9	6	3¾	9	6	—	21	—
10	6	17½	10	6	3	14	—
11	7	11¼	20	13	3	—	—
12	8	5	30	20	2	14	—
13	8	18¾	40	27	2	—	—
14	9	12½	50	34	1	14	—
			60	41	1	—	—
28	19	5	70	48	—	14	—
56	38	10	80	55	—	—	—
84	57	15	90	61	3	14	—
			100	68	3	—	—
			200	137	2	—	—

APPENDIX.

AMONG the variety of improvements that may be suggested for the interest of Mining, those certainly are most beneficial, which tend to the perfection of mechanicks and hydraulicks; for had there not been great progress made in those branches of philosophy within the last improved ages of science, Mining would still consist of merely digging a few fathoms deep, and raising the stuff and water, by dint of human labour.

About four-score years back, small wheels of twelve or fifteen feet diameter, were thought the best machinery for draining the Mines; and if one or two were insufficient, more were often applied to that purpose, all worked by the same stream of water. I have heard of seven in one Mine, worked over each other. This power must have been attended with a complication of accidents and delays. However, soon after the above date, Mr. John Costar, of Bristol, came into this county, and taught the natives an improvement in this machinery, by demolishing those petit engines, and substituting one large wheel of between thirty and forty feet diameter in their stead.

Hitherto we are all assured, that a large water wheel engine, if water is plenty and cheap, is most effectual and steady for the purpose of draining our Mines; but this power is limited; and beyond a certain gauge we dare not undertake. We know, that if we add to our power, we experience a loss in time or motion, more than equivalent to the acquisition. Upon this principle we understand, that a thirty-eight feet wheel, or thereabout, is the best medium we can prescribe to ourselves; pursuant to which we know, that, beyond a certain depth, we cannot sink with ease and conveniency to our interest; and that another power becomes necessary for our purpose.

It should seem as if we had been led by the kind hand of Providence in those discoveries; for as soon as we found out the ne plus ultra of the power of water, and the necessity of further

further improvements in hydraulicks, a new and more ſcientifick machinery preſented itſelf to the attention of the Miner. For want of another piece of machinery, we had been ſtinted to a certain depth, beyond which the ſucceeding generation by the water wheel and bobs would be unable to ſink. So that, happily for us and our poſterity, Mr. Newcomen's invention of the ſteam fire engine, even in the weakneſs of its infancy, promiſed that future excellence to which it is ſince arrived, whereby we are enabled to ſink our Mines to twice the depth we could formerly do by any other machinery.

Since the improvement of this machine's working itſelf, by opening and cloſing the regulator and injection cock, moſt other attempts have been very unſucceſsful. The vaſt conſumption of fuel in thoſe engines, is an immenſe drawback upon the profits of our Mines. It is a known fact, that every fire engine of magnitude conſumes to the amount of three thouſand pounds worth of coal in every year. This heavy tax upon Mining, in ſome reſpects, amounts to a prohibition. No wonder then, that we ſhould be more deſirous to leſſen the expence of maintenance in thoſe devouring automatons, than frugal in their erection. Many trials of mechanical ſkill have been made by our engineers, to very little purpoſe, for the total application of heat and the ſaving of fuel. The fire place has been diminiſhed, and enlarged again; the flame has been carried round from the bottom of the boiler in a ſpiral direction, and conveyed through the body of the water in a tube (one, two, or three) before its arrival to the chimney; ſome have uſed a double boiler, ſo that fire might act in every poſſible point of contact; and ſome have built a Moorſtone boiler, heated by three tubes of flame paſſing through it.

Indeed, the only improvement which has been made in the fire engine for thirty years paſt, the publick will very juſtly attribute to the ſagacity of Mr. Watt, whoſe ſkill in pneumaticks, mechanicks, and hydraulicks, is evidenced by the powerful application of elaſtick vapour, and by making a more perfect vacuum, nearly like that of the barometer, in his new conſtructed fire engine.

But before I can explain Mr. Watt's engines, it is neceſſary to premiſe a ſhort account of the imperfections of the common ſteam engines, and their cauſes.

The

The steam, or vapour, which arises from water confined in a close vessel, and heated a few degrees above the point at which it boils in the open air, becomes an elastick fluid uniform and transparent, about half the gravity of atmospherick air, very much greater in bulk than the water of which it is composed, and capable of being again reduced to water, when brought into contact with matter of a less degree of heat than itself.

The pressure of the atmosphere, or any equivalent resistance, prevents the production of steam, until the water be heated to 212 degrees of Fahrenheit's thermometer; but when that pressure is removed, or the water placed in a vessel exhausted of air, steam is produced from it, when it is colder than the human blood. On the contrary, if water be pressed upon by air or steam, which are more compressed than the atmosphere, a degree of heat above 212 degrees is necessary for the production of steam; and the difference of heats, at which water boils under different pressures, increases in a less proportion than the pressures themselves: so that a double pressure requires less than a double increase of sensible heat.

The experiments which have been published concerning the bulk of water, when converted into steam, are erroneous, and the conclusions drawn from them make that bulk greater than it really is. It has been known for some time, that water would boil in an exhausted receiver, at a low degree of heat; but Mr. Watt was the first that made a regular set of experiments upon the subject, and determined the progression in which the heats followed under various pressures; and, at the same time, made experiments that were decisive upon the true bulk of steam, when compared to the water it is composed of. The result of these experiments he intends to lay before the publick, in a treatise upon that subject.

If we consider the common steam engine, we shall find it defective; first, because the vacuum is produced by throwing cold water into the cylinder to condense the steam; that water becomes hot, and being in a vessel partially exhausted produces a steam, which in part resists the pressure of the atmosphere upon the piston, and lessens the power of the engine. The second defect is the destruction of steam, which unavoidably happens upon attempting to fill a cold cylinder with that fluid: for the injection water, at the same time that it condenses the steam, not only cools the cylinder but remains there, until it be extruded at the eduction pipe, by the steam which is let in to fill the cylinder for the next stroke; and that steam will be condensed into water as fast as it enters, until all the matter it comes into contact with be nearly as hot as itself.

Every attempt to make the vacuum more perfect by the addition of injection water, will cool the cylinder more effectually, and cause a greater destruction of steam in the next filling; and if the engine hath already a proper load, the destruction of steam will proceed in a greater ratio, than the increase of power by the amendment of the vacuum.

Though it appears, that the constructors of steam engines have never investigated these causes; yet they have been so sensible of the effects, that a judicious engineer does not attempt to load his engine with a column of water, heavier than seven pounds for each square inch of the area of the piston.

Mr. Watt's improvement is founded upon these, and some other collateral observations. He preserves an uniform heat in the cylinder of his engines, by suffering no cold water to touch it, and by protecting it from the air, or other cold bodies, by a surrounding case filled with the steam, or with hot air or water, and by coating it over with substances that transmit heat slowly. He makes his vacuum to approach nearly to that of the barometer, by condensing the steam in a separate vessel, called the Condenser, which may be cooled at pleasure without cooling the cylinder, either by an injection of cold water, or by surrounding the condenser with it, and generally by both. He extracts the injection water and detached air, from the cylinder or condenser, by pumps which are wrought by the engine itself, or he blows it out by the steam. As the entrance of air into the cylinder would stop the operation of the engines, and as it is hardly to be expected that such enormous pistons, as those of steam engines, can move up and down, and yet be absolutely air tight in the common engines; a stream of water is kept always running upon the piston, which prevents the entry of the air; but this mode of securing the piston, though not hurtful in the common ones, would be highly prejudicial in the new engines. Their piston is, therefore, made more accurately; and the outer cylinder having a lid which covers it, the steam is introduced above the piston; and when a vacuum is produced under it, acts upon it by its elasticity, as the atmo-

Haſtulla, ſignifies a chip or ſegment of wood cut off from a greater piece. (Vid. Pref. p. 15. Leland's Itinerary, vol. vii. 1769). Stull, a Bunding in Derbyſhire.

Assistants. The commons or lower houſe of convocation or parliament of Tinners. Each Convocator appoints his own Aſſiſtant, who is generally ſuppoſed to be a gentleman of veracity, integrity, and underſtanding in all Mining affairs. There are twenty-four Convocators, and twenty-four Aſſiſtants every convocation. See Stannaries.

Astyllen. A ſmall ward or ſtoppage on purpoſe in an Adit or Mine to prevent the free and full paſſage of the water by damming it up to a certain height, though not entirely to ſtop its current. Alſo, a kind of hedge or rude wall-work to ſeparate Lode and Deads from each other when brought to graſs. Alſo, a hedge under-ground, as a wall to prevent the running of Deads.

Attal, Attle, Adall, Addle. Corrupt, impure, of no value, off-caſts, Deads, or refuſe parts of the working that the Miners find under-ground on reaſſuming an old Adventure; that earth alſo which moulders away and falls down to the bottom of the Shaft, or pit, is called Attal, and ſo is all the ſtony earth broke in Mining which is not of a veiny nature. (Waſtrey or Deads in Derbyſhire).

Attall-Sarazen. Saxons or Jews off-caſt. (Carew's Survey).

Axletree. A thick piece of timber in form of a cylinder with a large rope wound obout it, and with which they bring up the work or Ore, and uſually let the men deſcend and come up; but the windlaſs includes the axle-tree with its appurtenances, as layers, upſtanders, ſtays, and brace boards—Defined—Stows in the north of England, which are ſeven pieces of wood (ſet up on the ſuperfices of the earth) faſtened together by pins of wood. Two are called Soultrees; two Stow-blades; two Hang-benches; and a Spindle; theſe Stows give a Miner, or any perſon who owns them, as good right to a meer or meers of ground (ſo that every meer has a pair of Stows ſet on them) as a deed of conveyance doth to any purchaſer.

B

Back—Of the Lode. That part of the Lode which is neareſt and uppermoſt towards the graſs or ſurface. (The Roof, Derbyſhire).

Bal. A ſhovel, a plague, a place of digging; Balas, to dig—Palas, idem. (Borl. Vocab.) when many people are employed in a Mine of note, in ſpaling, and ſorting the Ore, where it is brought to graſs, then they ſtile this place where the concourſe of people meet and work, by the name of the Bal, eſpecially if the place be ſeated on an eminence, for they ſay, "A perſon is "gone up to Bal;" but if the place or Mine lies low, it is uſual to ſay, "He "is gone to Moor;" if in the valley, they ſay, "He is gone to Coomb." Baly, ſignifies, To caſt up.

Bar. Any courſe or vein which runs acroſs a Lode or Mine is often termed a Bar; but they ſometimes meet with a very hard kind of ſtone, called an Ire-ſtone, which forms a ſort of courſe like as it were a Lode, but perhaps ſeveral fathoms wider: this is named a Bar. Bar-Maſter among the Lead Miners, is he which keepeth the Gage or diſh to meaſure the Miners Ore, he or his ſervant being preſent when meaſured. (Houghton's Rara Avis, &c.)

Bargain. See Fathom.

Batch. A parcel or quantity of any thing. "A Batch of Tin"—"A Batch "of Bread," &c.

Beat—"away the ground." Signifying the working away on the courſe of the Lode: or the ſtopeing away any ground in a Mine.

Beu. Alive. (Corniſh).

Beu-heyl. A live ſtream, i. e. rich for Tin.

Binder—Or Timber-man, ſo called, who undertakes to bind and keep a Mine open, or prevent any part from cruſhing or falling together.

Bing. See Cobb.

Black-jack. See Mock-Lead.

Black-Tin. Tin Ore, triturated, waſhed, and clean for ſmelting.

Block-Tin or White-Tin. Is Tin brought to its fineſt purity by ſmelting.

Blowers. The perſons that melt Stream Tin with charcoal fires, excited by bellows worked by water wheels.

Blowing-House. The houſe wherein the furnace for blowing is. (Blaſt-Houſe in Derbyſhire).

Borier An inſtrument of iron ſteel-pointed to bore holes with in large rocks, in order to blow them with gunpowder.

Bottoms. The deepeſt working parts of a Mine that is wrought either by ſtopeing,

Gatchers. The after leavings of Tin. See Loobs.

Glist. A ſhining black or brown Mineral of an iron caſt, ſomewhat like Cockle.

Gossan. A kind of imperfect Iron Ore, commonly of a tender rotten ſubſtance, and red or ruſty iron colour. It is often found ſhallow in Tin, Copper, and Lead Mines, and is the proper Nidus or Matrix for the two latter. It is an upper covering to the Ore, levels above thirty fathoms, and is very abundant; whence thoſe Lodes are called Goſſan Lodes.

Gounce. See Strekе, and the chapter on Stream Tin.

Grain Tin. The Ore of Tin that is ſometimes dug very rich in the form of grains or pebbles, or elſe in larger pieces, compoſed of many ſuch diſtinct grains, united in one entire maſs, always of a black or dark roſin colour, pointed like diamonds. Alſo, the pureſt and fineſt block or white Tin, ſmelted with charcoal in the blaſt or blowing-houſe furnace, which never had any brood or foreign mixture in the Mine. Grain Tin is peculiarly produced from ſtream work, and is worth ſeveral ſhillings ⅌ ⊕ more than Mine Tin.

Grant. See Sett.

Grass, or at Graſs, ſignifies on the ſurface of the earth. "Is Tom Treviſcas "under-ground? No; he's at Graſs." A Graſs Captain is an Overſeer of the workmen above-ground, as the bottom or under-ground Captain ſuperintends his men down in the Mine.

Grate. An iron plate punched full of ſmall holes; which belongs to the ſtamping mill, and ſizes the ſtampt Ore, becauſe it muſt all paſs through theſe holes by a ſmall ſtream of water.

Greut or Grit. A kind of foſſil body, of ſandy rough, hard, earthy, particles.

Griddle. A large wire ſieve, uſed inſtead of a hurdle, for ſifting and ſorting of Copper Ore, as it riſes from the Mine. Erckern calls it a Ratter, or Riddle, Screen or Sieve, to ſeparate the clean from the unclean Ores before they come to the fire. "This inſtrument doth "unriddle them by ſeparation: and for "the word ſcreen, it is doubtleſs from "ſecernere to divide, and ſieve from "ſegregare or ſever." Pettus on the word metallick.

Grouan. (Grou, Corniſh) Gravel, rough ſand. Grouanen, a pebble. Hard Grouan is Granite or Moorſtone. (Gronſten, Swediſh) Soft Grouan is the ſame materials in a lax and ſandy ſtate. Grouan Lode, any Tin Lode which abounds with this gravel. Grouder, a mixture of Grouan and clay, much uſed for ſcouring of timber-ware in houſewifry.

Ground. (See Country, and Shut). We ſay, a hard rock or Stratum is "Hard Ground." On the contrary, ſoft clayey Ground they call "Fair "Ground;" and if fair, yet firm to ſtand without timber, "Feaſible "Ground."

Guag. (Hunger, emptineſs; ac idem, Leary, Corniſh). Tinners holeing into a place which has been wrought before, call it "Holeing in Guag."

Gulph of Ore. Where a Lode throws up very great quantities of Ore, and proves laſting and good in depth, they ſay, "They have a gulph of Ore."

Gunnies—means breadth or width. A ſingle Gunnies is three feet wide; a Gunnies and a half is four feet and a half; and a double Gunnies is ſix feet wide. The former vaults or cavities that were dug in a Mine, are termed "The old Gunnies;" and if they are full of water, they are ſometimes called "The Gunnies of water;" yet more commonly "A Houſe of water.

Gurt. A fret or channel made by great rain or floods in a highway; alſo, a channel to carry off water from one place to another for dreſſing of Copper Ore, Tin, or the like. Gurt, in Corniſh, implies large, great. "Gurt "Mawr of Vuſs," Great root of furze.

H

Halvans, Halvings, Hanaways. All which names imply the refuſe Ore, or the poor Ore and Stone after the prime Copper Ore or Crop is firſt taken out; but they often cull over theſe Halvans again, and take more Ore out of them, which is called Halvan Ore. (Halvans, waſte hillocks, North of England). The poor refuſe part of Tin-ſtuff goes not by this name, but that of Leavings, or Caſualties.

Heads. See Stamp-heads.

Heave. See plate of Heaves in Goonlaz, &c. and book ii. chap. iii.

Hewns. The ſides of a calciner or burning-houſe furnace, from their being formerly built with hewn Moorſtone.

Hoggan. In Corniſh ſignifies a Hawthornberry; alſo, any thing mean or vile: but here it means a Pork Paſty; and now indeed any Tinner's paſty that he carries

down into the bottoms; alſo, to convey water acroſs Shafts, Drifts, and Gunnies, and for conveyance to any place for driving engine or mill wheels.

Layer—and laying of Tin. See Serving.

Leader. A branch, rib, or ſtring of Ore, that leads along to the Lode; or elſe if it be in the vein, and points, or leads away, ſo that they hope for a parcel or bed of Ore by following it, then this ſtring is a Leader or Guide; moreover when they purpoſely drive on, and follow veiny natured ſtrings, though without any Ore or life in them, yet ſuch are Leaders to follow. See Lode.

Learys—or lear; emptineſs. Old men's workings. Vide Gloſſary Pope's Shakeſpeare.

Leat. A water courſe, or level for conveyance of water, to engine or mill wheels.

Leavings—or Caſualties, in Tin, is the ſame as hanaways of Copper or Lead Ores, both being gleanings: but it rather implies the very minute Tin, that flows away with the water, in dreſſing the crop or prime Tin; but being gathered together is redreſſed to cleanſe it from its impurities and ſlime, &c.

Levelling — and Levels. The art of finding a true Level to convey water from one place to another, or elſe to find the Level or depth of an Adit at a prefixed place.

Life—ac idem, Alive; which ſee.

Lifters—are ſolid pieces of aſh timber 8 or 9 feet high, ſhod with iron ſtamp-heads for pounding the Tin-ſtuff, &c.

Little-Winds. (A ſump in ſome parts of England) An under-ground Shaft, ſunk from a horizontal drift, by which the top of the Winds communicates with the ſide or bottom of the graſs working Shaft.

Liver—or ly-very ſtone. A hard liver-coloured ſtone, and in a Lode is very hurtful.

Lode. (Main Rake, N. England) The word Lode is an old Anglo-Saxon word, idem ac, Lead; ſo Lode-ſtone, quaſi Lead-ſtone: ſee Lye's edition of Junius ad verbum. Any regular vein or courſe, either metallick or not; but more commonly it means a metallick vein: and being occupied and proving good, may indifferently be called a Lode, Mine, or Work.

Lode-Plot. A Lode that underlies very faſt or horizontal, and may be rather called a Flat Lode.

Lofty Tin—in contradiſtinction to Floran Tin, for Lofty Tin is richer, maſſive, and rougher, and not ſo weak or imperceptible in the ſtone, or in powder on the ſhovel.

Loobs. Tin ſlime or ſludge of the after leavings, or leavings ſlime.

Lord of the Land or Fee. The perſon in whoſe land the Mine is; therefore, the part which he reſerves to himſelf for liberty to work a Mine in his land, is the one-ſixth, one-ſeventh, one-eighth, or any other proportion free of expence, and called the Dues, Diſh, which ſee.

Lost-Slovan. (Loſt, a tail, a rump, Corniſh) Vulgo, Low-ſlovan; the beginning of an Adit, though the tail or end; that part which lies open like a trench, before they drive under-ground.

M

Mad-Water. Water that has been drawn from a Shaft, or any part of a Mine, and returns back again to the ſame place from whence it was drawn, is called Mad-Water, and implies a great want of ſkill in the managers.

Materials. All tools and tackle, timber and implements, that belong to a Mine; and in large Mines a perſon is appointed to take care of them, who is called the Material-Man.

Meat-Earth—Soil; the ſuperficial earth, fit for agriculture.

Mock-Lead. Wild Lead, black Lead, black Jack. A ponderous black Mineral, which does not readily incorporate in the fire. A Zinc Ore.

Moor. (See Bal) This wood ſignifies a root, or a quantity of Ore in a particular part of the Lode; as "A Moor "of Ore." "A Moor of Tin."

Moorhouse. A hovel built with turf for workmen to change cloaths in. A Coe, Derby.

Moorstone. See Grouan.

Mun. Any fuſible Metal; unde Dunmwyn, a hill of Metals; unde Dunmonii, the Corniſh Britains.

Mundick. An exceeding ponderous Mineral, whitiſh, beautiful, and ſhining, but brittle. Pyrites; Marcaſite, &c. too well known for deſcription here.

N

Needle. A piece of ſtout iron wire, uſed to make a touch-hole with in blowing of rocks with gunpowder. A pricker, Yorkſhire.

Night-Pair. See Day-Pair, and Core.

Nocking. Knocking. See Cob.

O

Old Men's Workings. See Learys.

Ore. Earth. (See Doar) Round Ore; rough, or Row Ore; ſtraked, ſtamped, bucked, jigged, and ſlime Ores; which ſee.

Ore-Plot. (See Plot) The Ore Plots at graſs; where they keep apart the dreſſed Ore for ſampling, &c.

Owners. See Adventurers.

P

Packing. A further or final dreſſing of Tin or Copper Ore, by putting of either in a kieve or vat with water, often ſtirring the water, and ſtriking the ſides of the kieve, by which means the heavy particles ſink to the bottom, and the light waſte ſwims uppermoſt; which is afterwards ſkimmed off, and thence called the Skimpings; which ſee.

Pair. Any indeterminate number of Miners who work together in a Mine in a Pitch upon Tribute, in a But-Bargain, &c. Alſo, they call any number of horſes, from five to twenty, a pair of horſes. See Core and Day-Pair.

Parcel. A parcel of Ore, is a pile or heap of Copper dreſſed for ſale.

Peach. Peach-Stone, a bluiſh green ſoft Stone. When a Lode is moſtly compoſed of this ſort of Stone, it is called a Peach or Peachy-Lode.

Pednan. Pedn or Pen. (Corniſh). A head or promontory. In Mine affairs, the Pednan is the head of the buddle where Tin is dreſſed.

Pick. The common name of a Tinner's pick-axe; alſo, to pick or cull the good Ore from the bad by hand; whence thoſe who do it, are called Pickers.

Pile—Of Ore. A heap of Ore; a parcel of Ore; and ſometimes a Dole of Ore.

Pillar. An upright piece or part of the Lode left to ſupport the incumbent weight.

Pillion. The Tin which remains in the ſcoria or ſlags after it is firſt ſmelted, which muſt be ſeparated and remelted.

Pioneer. An able Pickman or underground Tinner.

Pipe. See Bunny.

Pit. A Shaft, Dippa, Sumph, or Coſtean Pit; all Pits of different depths.

Pitch. Any part or portion of a Mine, being a few fathoms in length on the courſe of the Lode, is ſo called: and if granted to the Miners for raiſing the Ore at ſo much out of the pound ſterling, it is called, "A Pitch upon Tribute;" if it is higher up in the Mine at a ſhallow level, it is called, "A Pitch upon the Backs;" and lower down, "A Bottom Pitch."

Plot. (Vulgo, Plat). "To cut a Plot," is to make room, or ſquare out a piece of ground by the ſide of the Lode or Shaft, for holding the broken work or deads before they are brought to graſs; or for other convenient purpoſes. (A Plot, a Brigging-place in Derbyſhire).

Plump. A corruption of the word Pump.

Podar. Rotten, corrupt; Mundick—Copper Ore was formerly called Podar.

Pokkers and Jetters. Are blocks or pullies, over which the ſweep rods of ſome engines move and play. (See Flats). Pokkia (Corn.) unde Pokker, to thruſt, poke.

Pol-Rôz. (Pol, a pool; Rôz, a wheel, Corniſh). The pit under a mill-wheel; the wheel-pit.

Pol-Stean. (Pol, a head alſo; Stean, Tin. Corniſh). A Tin pit. A miry head. (Carew).

Powdered. Powdered Ore. When a Lode is ſpotted with Ore, or ſtones of Ore, but in ſo diſſeminate a quantity and appearance as to be ſcarce worth the charges of dreſſing, they ſay, "It is Powdered Ore, or Dredged Ore."

Pride—Of the Country. When Ore is found near the ſurface, at a level where it is rarely met with, and in great abundance and very rich; alſo, when a bunch of Ore is found out of a Lode like ſtones ſcattered in a quarry, they ſay, "It is the Pride of the Country."

Pryan. (From Pryi, Clay, Corniſh). Pryan Ore, Pryan Tin, Pryan Lode; that which is productive of Copper Ore or Tin, but does not break in large ſolid ſtones, only in groſs pebbles, or ſandy with a mixture of clay.

Puppy. The ſet or tier of pumps below the Lilly under-ground.

Purser. A perſon deputed to keep and adjuſt the accompt-book, to receive the coſts, and diſcharge the demands on the Mine; uſually, both treaſurer and ſecretary of a Mine.

Q

Quarey. When a Lode or Stratum breaks in large hard rocks, being jointed as it were, it is called a Quârey Lode or Stratum, from its joints or Quâres.

Wheel-Pit. A very large but ſhallow pit that is ſunk in the ground, or at ſome depth under-ground, in order to erect a water-wheel and engine in it.

Whele. Id. Huel, or Wheal. See Huel.

Whym or Whim. A horſe engine. Sometimes its uſe is to draw water; but moſtly it is intended to wind or roll up the work out of a deep Mine, being wrought by horſes. An Engine, Derbyſhire.

Whym-Round. A Volt, (Johnſon). Engine-Race, North of England.

Whym-Shaft and Whym-Kibbal. See Shaft and Kibbal.

Whip. See page 179.

White Tin. Block Tin, or purified Tin, brought to its ultimate perfection by fire.

Wild Lead. See Mock Lead.

Windlass. See Axletree.

Winds. See Axletree, Little-Winds. The Turn, North of England.

Work. (From the Teutonick, Werke; a Mine). Work often ſignifies the Ore or deads, or other earth or ſtone, that is broken in a Mine, and brought up to graſs. This word often implies the Mine itſelf, as when they ſay, a Rich Work, or a Poor Work, inſtead of a Rich Mine, or a Poor Mine. A Tin Work. A Copper Work. They likewiſe term Copper ſmelting furnaces, Copper Works.

Working-Big. Is the ſpace of about two feet and a half wide, ſo that a man may have room enough under-ground in a Lode or in a Drift to uſe his Pick and other tools without breaking any of the contiguous Strata not of a veiny nature: hence they ſay, a Lode is a Working-big, that is, two feet and a half wide.

Z

Zighyr. (Slow, Corniſh) When a very ſmall ſlow ſtream of water iſſues through a cranny under-ground, it is ſaid to Zighyr or Sigger.

F I N I S.