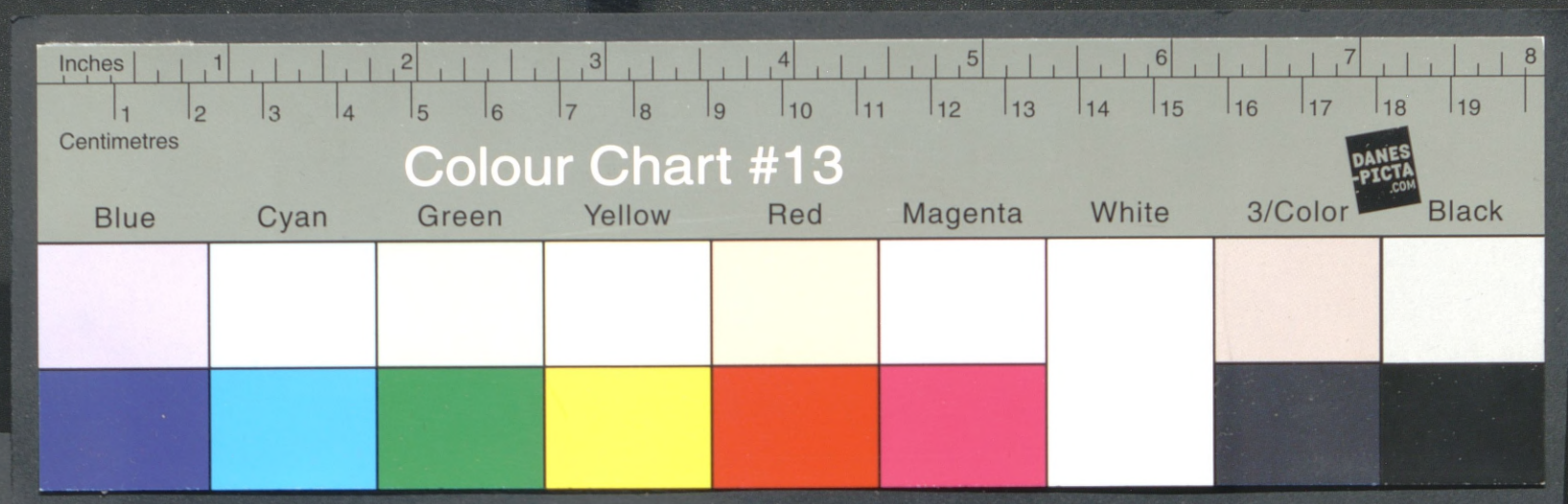
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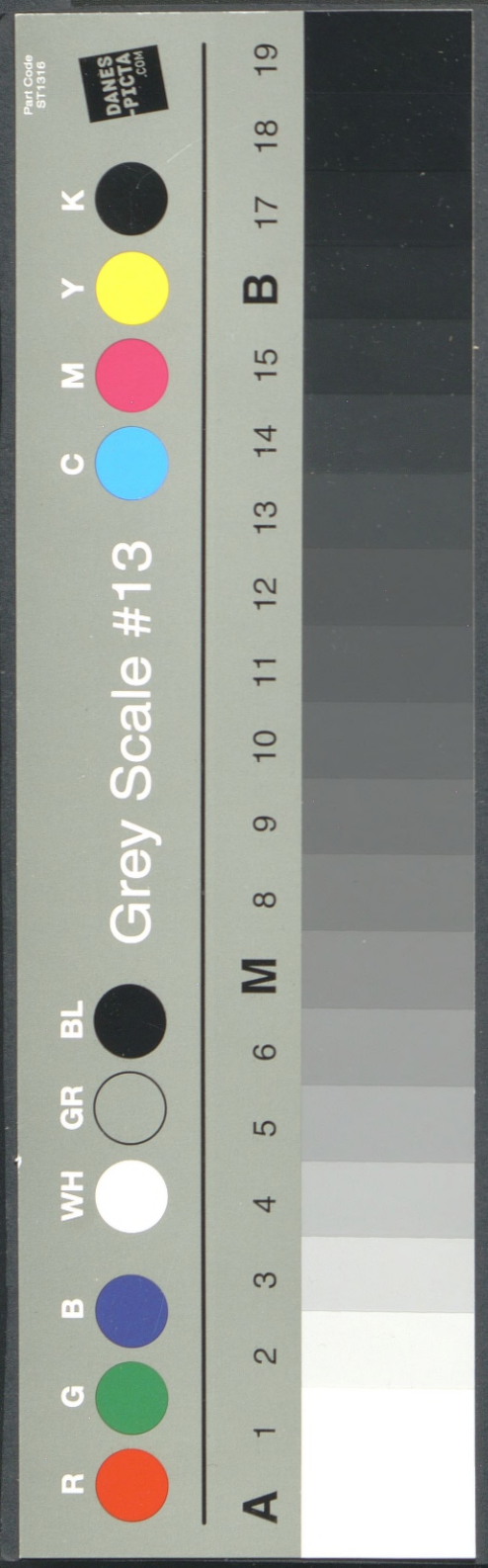
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THE

GREAT ART

OF

ARTILLERY

OF

CASIMIR SIMIENOWICZ,

Formerly LIEUTENANT-GENERAL of the Ordnance to the King of *Poland.*

Tranſlated from the FRENCH,

By *GEORGE SHELVOCKE,* Jun. Gent.

Illuſtrated with Twenty Three Copper Plates.

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The TRANSLATOR's PREFACE.

IT is ſaid that Prefaces to Books, as well as their Title-Pages, are too often guilty of promiſing much more than ever the *Readers* can diſcover in them: But this ſhall not be the Caſe here; for what I intend to advance in Favour of this *Work*, ſhall be as ſimple as its Title. I ſhall only ſay, That it were to be wiſhed, that the greateſt part of Thoſe, who have undertaken to inſtruct the Public in the various Branches of the *Practical Arts*, had been indued with Knowledge or Induſtry enough, to qualify them for the Management of their particular Provinces with ſuch Addreſs, and to ſuch uſeful Purpoſe, as our Author. This is all I need ſay, concerning Him or his Work; for it would be both vain and impertinent in me, to take up your Time with an *Encomium* upon either; ſince the Authority of *Caſimir Simienowicz* has been formerly, and is ſtill, as it were Sacred amongſt *Pyroboliſts* and *Fire-Workers*; as is particularly evident from His having

ing been long ago tranſlated into the moſt noted of the *European* Languages; and from the joint Concurrence of the preſent Judicious in theſe Matters, by the common Suffrage of whom he is allowed to be the Father of Sound and Intelligent *Pyroboliſts*.

My Deſign therefore in this *Preface* is only to give you a very brief Account of this *Tranſlation*; to which I ſhall annex a few Lines relating to the Hiſtory of *Saltpeter*, which I ſhall borrow from very good Authority; and which I promiſe myſelf will be both New and Acceptable to moſt of Thoſe, who apply Themſelves to the Study and Practice of the *Military Pyrotechnics*.

This *Tranſlation* then was undertaken and compleated purely by the Encouragement of Colonel ARMSTRONG, the preſent *Surveyor-General* of his MAJESTY's *Ordnance*, Who conſidering with Himſelf, That tho' our Language abounds in Learned Tracts on almoſt all the Subjects that are truly Uſeful, It is ſtrangely defective in ſuch as might tend to the Preſervation of our Liberties, and the Honour of our *Arms*, amongſt our Neighbours; the moſt Warlike Nations in the World! He concluded that by naturalizing the moſt celebrated *Author* in this Kind, a great Step would be taken towards recovering our *Pyroboliſts* and *Fire-Workers*, from the Lethargy they ſeem to have been wrapped in for many Years paſt; and towards exciting Them to an Emulation of their Glorious Anceſtors, who always endeavoured to be Foremoſt in all *Martial Knowledge*. And ſince the *Genius* of our Nation is ſtill equally inclined to *War* and to *Peace*, it is to be hoped, That our *Military Artiſts* will as readily improve upon this *Stranger*, as our *Civil Artiſts* have upon innumerable *Foreigners* in their Way.

But it may be asked by Thoſe, who have heard that this *Work* was originally written in *Latin*, why it was not rather tranſlated from that Language, than from the *French*? To give a ſhort Anſwer to this Query, I muſt

tell

tell you, that it could not be procured in *Latin:* And it will not appear ſtrange that there ſhould be ſuch a Scarcity of it, in its Original Tongue; if it be conſidered, That our *Author* was of *Poland*, where the *Latin* is in univerſal Uſe, and where the Profeſſors of this *Art* are very numerous, eſpecially in its *Recreative Branches*, which are practiſed by the *Poles* as a common Myſtery, or Trade; ſo that notwithſtanding there may be ſeveral Thouſands of this *Work* extant in the *Latin* Tongue, they are particularly cloſeted up by that Nation as an invaluable Treaſure.

If I could have procured one of the Original *Copies*, it would doubtleſs have ſaved me a great deal of Trouble; for the *French* Tranſlation is now grown very obſcure and obſolete; and what contributes to make it almoſt Unintelligible in many Places, it is the moſt Careleſsly-printed Book I ever ſaw, ſcarce a Page of it being free from groſs Typographical Errors.

Under theſe Diſadvantages I laboured throughout this whole Tranſlation; ſo that if any *Inaccuracies* have eſcaped me, the *Candid Reader* would forgive them, as ſoon as diſcovered, if He would but conſider how eaſily I may have been miſ-led into them, notwithſtanding all the Care I may have taken to guard myſelf againſt them; and if at the ſame Time He did but know what Pains I have really been at, to purge my *Original* of a vaſt Number of Erroneous Blemiſhes of all Sorts, that the Whole might anſwer the Deſign of this Undertaking. But I hope that all the Material Miſtakes I have fallen into, will be corrected in my Table of *Errata.* And here it may not be Unſeaſonable to inform you, That the Confection and Proportions of the ſeveral *Compoſitions* have been compared by a Friend with the *German* Tranſlation; for without ſome ſuch Help, it would have been next to Impoſſible to have rectified what was amiſs in that Important Article.

In a word, you have here the compleat Body of my *Original*, in the cleareſt and moſt familiar Style I am Maſter

ſter of, as much as poſſible diveſted of the tedious Circumlocution and Prolixity of the *French*, and expreſſed in ſuch *Terms* of Art and Science as ſeem to be moſt in Uſe with the preſent *Learned*.

I ſhall now enter upon what I promiſed you with reference to *Saltpeter*; to the End, that you may be as well verſed in whatever relates to that wonderful *Salt* and *Soul* of *Artillery*, as it becomes a profeſſed *Pyroboliſt* to be: And I am the more encouraged to it; becauſe the *Latin* Quotations, which are interſperſed in the Treatiſe I ſhall here abridge, muſt render the Reading of it imperfect and unpleaſant to Thoſe who are not tolerable Maſters of that Language. What follows then, is the Subſtance of a Paper in Biſhop *Sprat*'s *Hiſtory of the* ROYAL SOCIETY, intitled *The Hiſtory of* Saltpeter *by Mr.* Henſhaw.

He ſays, " That whether the *Nitre* of the Ancients be " of the ſame Species with the *Salt*, which is commonly " known by the Name of *Saltpeter*, is variouſly diſputed " by very learned Authors: But by his Obſervations, and " by the Practice of Saltpeter-Men, and Refiners of *Salt-* " *peter*, He ſuſpects that the Confidence of thoſe who " hold them to be different *Salts*, proceeds chiefly from " their being unacquainted with the *Phænomena* or Ap- " pearances of *Saltpeter* in the Making and Refining of " it: And alſo to their comparing Double Refined *Salt-* " *peter* (of which *Gun-powder* is made) with that De- " ſcription of *Nitre* and *Afronitre*, in *Chap.* X. of *Book* " XXXI. of *Pliny*'s *Natural Hiſtory*, where he tells us, " That *Afronitre was almoſt of a Purple Colour*; and that " *the* Ægyptian Nitre *was brown, and gritty or ſtony*; ad- " ding afterwards that there were *Nitrariæ from whence* " *the* Nitre *came out of a yellow Colour*. This, Mr. *Hen-* " *ſhaw* ſays, is ſufficient to have hinted to any one but " moderately verſed in the Modern Way of ordering *Salt-* " *peter*, that the Ancients were not at all skilled in Re- " fining their *Nitre* from the *Earth* and common *Salt*,

" that

" that is uſually mingled with it; nor from that foul yel-
" low Oil, which it ſeems did accompany their *Nitre* as
" it doth our *Saltpeter* in great abundance; for *Pliny*
" takes Notice of it when he mentions the removing of
" *Nitre* (after it is grained) out of the *Nitrariæ*, ſaying,
" *Here alſo an Oil intervenes which is good againſt the Scab*
" *or Mange in Animals.* This greaſy Oil (which the
" Workmen were uſed to call the *Mother of Saltpeter*)
" Mr. *Henſhaw* takes to be the crude and unripe Part of
" it; and ſays, that it doth by Nature ſo wonderfully
" adhere to every Part elſe of *Peter* (it may be, ordained
" for the Nutriment and Augmentation of it) that the
" Separation of it is the ſole Cauſe of the great Charge
" and Labour that is required in refining of *Peter:* For
" if this Separation is not effected, the *Peter* will be yel-
" low or brown, or of ſome other dark Colour."

He then quotes a Paſſage from *Scaliger*, which is alſo quoted by our Author (namely) *For we have frequently obſerved a kind of Luſtre of a glimmering Purple in* Salis-pretræ Terris; *or in Saltpetrous Earths*; whereas *Caſimir* has it *Salispetræ Cirris*, or in the *Shivers of Saltpeter*; but it is likely that they may both be in the right. He then ſays, " That if a Saltpetrous *Lixivium* be boiled up to
" a Conſiſtence without filtring it thro' Aſhes, or giving
" the *Salt* leave to Chryſtalize, you may perhaps find
" ſomething not unlike the *Nitre* of the Ancients."

He then quotes this Paſſage from *Pliny*, " *There is a*
" *little* Nitre *found in ſome ſcorched Vales of* Media, *where it*
" *is called* Halmiragha: *And a leſs quantity of a coarſer Sort*
" *of* it *is alſo found in* Thrace *in the Land about* Philippi,
" *where it is called* Agrium. And then ſays, that a Refiner of
" *Saltpeter* gave him an Account parallel to what *Pliny*
" aſſerts; by telling him, that near *Sophia* and *Santa-Cruz*,
" and in ſeveral other Places in *Barbary*, he ſaw *Saltpe-*
" *ter* ſhoot out of the Surface of the Ground, as thick
" and white as Hoar-Froſt, on many barren and deſart

" Lands; but that this does not happen till the begin-
" ning of the Rains in *Auguſt* or *September*, and that it
" is the falling of the Rains which cauſes the *Salpeter*
" to ſhoot out in little Chryſtals; and that the People
" of the Country take it up as clean as they can, and
" ſell it to Merchants: And that, by the Relation of an
" *India* Merchant, it is much after the ſame manner that
" the Inhabitants of *Pegu* in *Eaſt-India* collect it and ſell
" it, ſaving that they refine it once before they deliver
" it to the Merchants.

The next Remark he takes out of *Pliny*, is this:
" *There are* Nitrous Waters *in many Places, but which*
" *cannot be condenſed or grained by the Heat of the Sun.*
" *The beſt is found in* Macedonia, *which they call* Chalaſtri-
" cum, *and is very pure and white, and nearly like* Salt.
" *There, is a* Nitrous Lake, *that has a Spring or Fountain*
" *of freſh Water riſing up in the Middle of it: In this* Lake
" *they find* Nitre *about the Time of the Dog-Days; when*
" *it begins to ſwim on the Surface, and ſo continues for nine*
" *Days; after which it ceaſes for nine Days; which being*
" *expired, it floats again as before, and then ceaſes as be-*
" *fore. If during thoſe Days that the* Nitre *is generated*
" *there happen to fall any Showers of Rain, they cauſe the*
" Nitre *to be ſalter than ordinary; but if any violent Winds*
" *ariſe they ſpoil it, becauſe they make the Water foul and*
" *muddy. There is a much greater Quantity of it made in*
" Egypt, *but it is not ſo good; for it is of a dark Colour,*
" *and gritty or ſtony, and made almoſt after the ſame Man-*
" *ner as common Salt; with only this Difference, that into*
" Salt-Pits *they pour Sea-Water, and into* Nitrariæ, *Water*
" *of the River* Nile.

Upon this, Mr. *Henſhaw* ſays, " It will be no diffi-
" culty to conjecture, how ſuch great Plenty of *Nitre*
" ſhould be found in the Places above-mentioned, if we
" conſider that Lakes are the Receptacles of Land-Floods,
" and that great Rains might eaſily bring it to the Lake

" in

" in *Macedonia* from the higher Parts in the Country " about it. And for the River *Nile* (he ſays) there " muſt needs be leſs Scruple concerning it, if we call to " mind that once in a Year it ſweeps with an impetuous " Overflow the burnt and barren Deſarts of *Africa* under " the Torrid Zone; where, by the Relation of Travel- " lers, thoſe Sands are viſibly full of *Nitre*; and thoſe " few Springs and Wells that are found there, are for that " Reaſon ſo bitter, that the *Moors* and their Camels are " forced to make a hard Shift with them in their long " Journeys.

" He ſays, he drew good *Rock Peter* out of thoſe *Sti-* " *ria* which are uſually found hanging in arched Cellars " and Vaults." And here it may not be improper to remark that the Word *Stiria* ſignifies an Icicle, or any thing like it; whereas *Scaliger* expreſſes himſelf with reference to this Matter by the Word *Stria*, which in this Caſe properly ſignifies a Furrow as I have rendered it in the firſt *Chapter* of the *Second Book*: But I ſuppoſe it is found both in *Stiriæ* and in *Striæ*. However this be, I ſhall not waſte your Time with ſaying any Thing farther concerning it.

But to ſteer more directly upon our preſent Subject, *Saltpeter*; Mr. *Henſhaw* ſays, " It is likely that the Air " is every where full of a Volatile Kind of *Nitre*, and that " Lime and Plaſter do ſtrongly attract it, but Dew and " Rain convey much of it to the Earth; and that the " Clouds ſeem to be ſpread out before the Face of the " Sun, either to imbibe ſome Part of his Influence, or " to have a Salt generated in them to advance the Ferti- " lity of the Earth; and he thinks they return not with- " out a Bleſſing, in that he has more than once extracted " *Saltpeter* out of Rain and Dew; but in the greater " Plenty from the latter; and that even when it is ex- " tracted from Dew, it is accompanied with a greaſy pur- " ple Oil in great abundance; and adds, that upon Tryal

" he

" he found, that moſt ſtanding Waters, and even deep " Wells, have ſome ſmall quantity of *Saltpeter* in them; " and aſſures us, that he alſo found ſome in the Fallows " and in the Earth which Moles caſt up in the Spring. " He then continues, That tho' the Air and Water a- " bound with it in ſome degree, yet that it is not there " to be had in any Proportion anſwerable to the Charge " in getting it: And that tho' the Earth muſt neceſſa- " rily have great Quantities generated in or infuſed into " it, yet that in theſe Temperate Climates of *Europe*, it " is no ſooner dilated or diſſolved by Rain-Water, or the " Moiſture of the Earth, but it is immediately applied to " the Production or Nutriment of ſome Plant, Inſect, " Stone or Mineral, ſo that the Artiſt will find as little " of it in the Earth to ſerve his Turn, as he could in " the Air or in the Water.

He ſays therefore (in which he exactly concurs with our Author) " That the only Places where it is to be " found in any Plenty in theſe Northern Countries, are " Stables, Pigeon-Houſes, Cellars, Barns, Ware-Houſes, " and generally ſpeaking in any Place which is covered " from the Rain, which would diſſolve it, and make it " vegetate, as alſo from the Sun which rarifies it, and " cauſes it to be exhaled into the Air. In ſhort, he " ſays, that he was aſſured by an experienced Workman, " that no Place yields *Peter* in ſuch abundance as the " Earth in Churches, were it not an Impiety to diſturb " the Aſhes of our Anceſtors in that Sacred Depoſitory; " and in this he agrees perfectly with what our Author " ſays concerning the Deſarts of *Podolia*, in *Chap.* II. of " *Book* II.

" But even in this Caſe the Earth muſt be of good " Mold, and the better the Mold is, the more *Peter* is " produced; for in clayiſh or ſandy Earth, little or none " is found: And the freer Ingreſs the Air has the bet- " ter, ſo that the Sun be excluded: But if the Earth be

" in

" in itſelf never ſo good, if it be removed and laid upon " a Brick or Boarded Floor, it will not be ſo rich in *Pe-* " *ter*, as if it had free Communication with the Exhala- " tions of the lower Parts of the Earth.

" In any Place qualified as is above premiſed (he ſays) " you cannot miſs of good Store of *Peter*, if it has not " been drawn out in ſome Years before, which you will " quickly find after you have digged the firſt Spade-full " of Earth, by laying a little of it on the End of your " Tongue, and if it taſtes a little Bitter, you may aſſure " yourſelf of good Store of Mineral (as they uſed former- " ly to call *Saltpeter*)--------- If the Ground be good, it " continues Rich to ſix or eight Foot deep, and ſome- " times but not often to Ten.

" After the *Saltpeter* is extracted, if the Earth be laid " Wet in the ſame Place again, it will be twenty Years " ere any conſiderable Quantity grow there of it; but if " the Earth be well dried, it will come in Twelve or " Fourteen: And if the dried Earth be mixed with Store " of Pigeon's Dung, and mellow Horſe Dung, and then " tempered with Urine (as was uſual before we were ſup- " plied with *Peter* from *India*) it will be fit to dig up in " five or ſix Years. If Water be caſt upon Ground " which is fit to dig for *Peter*, it will only ſink the Mi- " neral deeper into the Earth; but he that ſhall throw " Soap-ſuds on it will deſtroy the *Peter* (as the Workmen " have a Tradition) and it very well deſerves a farther " Inquiry.

He concludes, " That the Generality of Authors are " of Opinion that *Saltpeter* and the Way of drawing it " out of the Earth, is a Modern Invention; but whether " it was originally owing to Chance, or to the Sagacity " of ſome great Wit, is as unknown as the Time it was " diſcovered. But (he ſays) it ſeems to have many Years " preceded the Invention of *Gun-powder*, which by the " *Germans* is aſcribed to *Conſtantine Autlitzer*, or *Berthold*

" *Schwertz*, a Monk of *Friburgh*; which in all Probabi-
" lity was not long diſcovered when the Inventor (as *Po-*
" *lydore Virgil* tells us) taught the Uſe of *Guns* to the
" *Venetians* at the Battle of *Foſſa Claudia*, when they ob-
" tained that notable Victory over the *Genoeſe*, *Anno*
" 1380. For there is mention made both of *Saltpeter*
" and *Aqua Fortis* in the Writings of *Geber*, a *Spaniſh*
" *Moor*, and an *Alchymiſt*; but at what time he lived is
" unknown; tho' it is certain he lived ſome Hundreds of
" Years before *Raimund Lully*, who about the Year
" 1333 publiſhed ſome of his Books, where he treats of
" *Saltpeter* and *Aqua Fortis*. In fine, Mr. *Henſhaw* ſays,
" it is no ill Conjecture of *Maierus*, That the foreſaid
" Monk being a skilful *Alchymiſt*, had a Deſign to draw
" a higher Spirit from *Peter* than the common *Aqua For-*
" *tis*, and that he might the better open the Body of
" *Saltpeter*, he ground it with *Sulphur* and *Charcoal*, by
" which Compoſure he ſoon became the Inventor of *Gun-*
" *powder*."

Thus far Mr. *Henſhaw* concerning the Hiſtory of *Salt-peter*; and I hope that what I have here tranſcribed, will prove acceptable to the curious *Pyroboliſt*, eſpecially if he never met with it before; and if he has, I doubt not but he will be of Opinion, that I have not done amiſs in preſenting it to the Peruſal of many, who perhaps might never otherwiſe have ſeen it; or at leaſt I flatter myſelf every one will acknowledge, that this curious Piece could never have been as it were revived upon a more proper Occaſion than the Preſent; ſince it may ſerve to clear up ſome Things, and confirm others, which are to be found in the following *Work*; which it will not only do, but alſo compleat what *Caſimir* has attempted upon this Subject.

As for Mr. *Henſhaw*'s Manner of Making and Refining of *Saltpeter*, I ſhall only ſay, that it is in the main the ſame with what you will find in this Treatiſe with reference to that Matter.

Thus

Thus we ſee that what is almoſt univerſally held to be the very Baſis and Generation of Nutriment, has by the reſtleſs and prying Curioſity of Mankind been perverted into the moſt fatal Inſtrument of Death and Deſtruction that has ever been diſcovered.

To conclude; you will obſerve, in peruſing this *Work*, That our Author propoſed to publiſh a *Second Part* of it, to ſupply what is wanting in this; but it ſeems, that either the Shortneſs of his Days, or the Multiplicity of his Buſineſs would not permit him to effect it: Wherefore I am to acquaint you, that what our Author has promiſed only, will be amply ſupplied by a GENTLEMAN, in every Reſpect qualified for ſo Great and Uſeful an *Undertaking*; and that you may ſoon expect ſuch a Continuation of this Subject, as will (allowing for the many Improvements reſulting from the Experience of the laſt *Wars*) more than anſwer all the Views of our Author with reference to the *Great Art* diſcuſſed in the following Sheets.

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ERRATA

ERRATA.

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OF

OF THE

GREAT ART

OF

ARTILLERY.

PART *the* FIRST.

BOOK I.

Concerning the CALIBRE SCALE.

THE firſt and principal Inſtrument uſed in *Pyrotechnicks*, or *Artificial Fireworks*, which we call the *Calibre Scale*, (according to the univerſal Term amongſt all *Pyrotechnicians*, or *Artificial Fireworkers*, as well *Spaniards* and *French* as *Italians)* is called by the *Germans*, *Maſtaab* or *Viſier-ſtaab*; by the *Flemmings*, *Talſtock*; but much more properly by the *Latins*, *Virga*, or rather *Regula Sphæreometrica*; and which, in Derivation from them, we will call in *Engliſh* the *Sphæreometric Rod* or *Scale*. We muſt conceive no other thing by the different Appellations above recited, than a certain Inſtrument or kind of Ruler, which has a near Reſemblance to a Parallelopiped Priſm, or rather to the *Fruſtum* of a ſquare Pyramid, which ought to be made of ſome Metal, or hard Wood, that will not eaſily bend; upon one of whoſe Superficies is a right Line, divided into unequal parts in a Stereometrical or Cubical Proportion, and nicely adjuſted to determine and examine the Weights of all Iron Bullets by their Diameters. This *Scale* or Ruler accordingly ſhews the Diameters of all Bullets made of the abovementioned

Metal, from the Diameter of a Bullet of one Pound, or from that of a *Loth* or Half an Ounce, *ad infinitum*; that is, as far as the Length of the Line can admit of. In like manner upon the Second and Third Superficies of this *Scale*, you have the Diameters for Bullets of Lead, or Stone, *&c.* of different Gravities, by which you may determine the Weights of Bullets made of thoſe Materials. The Fourth and laſt Superficies of this Inſtrument, ſhews the Meaſure of the *Rhynland Foot*, or (as ſome will have it) the *Old Roman Foot*, which is divided into twelve *Unciæ* or Inches, and with this we may meaſure not only all *Pyrotechnick* Bodies; but likewiſe all Sorts of Superficies, Planes, and Lines.

Having thus deſcribed the *Calibre Scale*, it is but reaſonable that we ſhould proceed to ſhew the different Methods by which it may be conſtructed; and alſo its particular Uſe in *Artillery*; of all which in the Order and Method following.

CHAP. I.

The Arithmetical Conſtruction of the Calibre Scale.

THERE are many and different Methods uſed by almoſt all Arithmeticians and Geometricians, as well Theoretical as Practical, and even among the greateſt Part of Mechanicks, in the Conſtruction of the Stereometric or Cubical Line (from whence our *Calibre Scale* takes its Original) or whenever they would divide any Line into proportional Parts according to the Cubical *Ratio*. In order to do this Arithmetically, you need only double, treble, *&c.* the firſt *Cube* as often as you think fit; and extract the *Roots* after the Manner I ſhall ſhew in the Sequel: But by the way I muſt obſerve that thoſe who practiſe this Science, as well as the reſt of the Mechanicks, have taken it into their Heads to avoid this Operation; becauſe of the Neceſſity of extracting the *Cube Root*, which is a little irkſome and difficult, and content themſelves with dividing their Lines into a Cubical Proportion by the Aſſiſtance of Tables, that have before been calculated by other Arithmeticians, which they freely make uſe of, in all their Operations. But ſince it is of no ſmall Importance to ſuch as would be perfect in this Art, to have a Knowledge of this Method; we ſhall here give ſome very ſuccinct Rules, relating to the *Cube Roots*, together with the Manner of making Stereometrical Tables; by means of which we ſhall eaſily conſtruct our *Calibre Scale*.

A Brief Method of extracting the Cube Root comprehended under the following Rules.

Arithmeticians term that a Cubical Number, which is made and produced by any Number multiplied into itſelf, and then the ſame Number multiplied by the Product. As for Example; if the Number Ten be multiplied into itſelf it will produce a Hundred, which if it be multiplied again by Ten it will give a Thouſand, which laſt Number we call a Cube; and Ten, which was the original Number, we call the Cube Root; this being once well underſtood, you will find it very eaſy to extract the Cube Root of any Number whatſoever, if you attentively obſerve the following Directions.

Firſt, you muſt have in your Eye a Table of the Nine firſt Cubes and their Roots, which may be eaſily form'd by multiplying the Nine ſimple *Integers* cubically, as demonſtrated in the following Table:

Roots.	Cubes.
1	1
2	8
3	27
4	64
5	125
6	216
7	343
8	512
9	729

2. In order to extract the Cube Root of any Number, as ſuppoſe 160|103|007; divide off every three Figures, of this Number, as you ſee above, beginning from the Right-hand towards the Left; which done, look into the Table of Cubes, for the greateſt Cube under 160, which you will find to be 125; therefore 5 being the Root of 125, ſet down 5 in the Quotient, and ſubſtract 125, its Cube from 160, and you will have a Remainder of 35, to which you muſt bring down the next Cube, *(viz.)* 103.

3. To find the next Figure of your Quotient, you muſt form a Diviſor; which is always done by trebling the Square of the Quotient; as for Example; 5 being multiplied by 5, makes 25, which is the Square of 5, which Square being multiplied by 3, produces 75; and this laſt Number is the Triple Square of the Quotient, which is to ſerve for a Diviſor: With this Diviſor divide the Reſolvend 35103, excepting (the two laſt Figures, *viz.)* 03, and you will have 4 for the ſecond Figure of the Quotient.

4. Then to find the Number which is to be ſubſtracted from the aboveſaid Reſolvend, you muſt ſet down in a Corner by itſelf, the Triple Square *(viz.)* 75, with two Dots to the Right of it, inſtead of Cyphers,

Cyphers, after this manner 75 . . ; then multiply 5, the firſt Figure of the Quotient, by 4, the laſt Figure found, and you will have 20, which being multiplied by 3 will give 60, which Number muſt be ſet under 75 . . one Place farther towards the Left Hand *(viz.)* the Cypher in 60 under the firſt Dot; then ſquare the laſt Figure found *(viz.)* 4, and it will give 16; which muſt be ſet under the two other Numbers, ſo that the laſt Figure 6 may ſtand under the laſt Dot; which done, add theſe three Numbers together, and they will make 8116, which muſt be multiplied by the laſt Figure of the Quotient *(viz.)* 4, and the Product will be 32464, which being ſubſtracted from the Reſolvend 35103, the Remainder will be 2639, to which you muſt bring down the next Cube, *(viz.)* 007, which being annexed to the ſaid Remainder you will have 2639007 for a new Reſolvend.

5. You muſt proceed upon every Operation by finding a new Diviſor; (which is always the Triple of the Square of the Quotient) therefore ſquare 54, the Number now in the Quotient, and you will have 2916, which Sum being trebled will give 8748, which muſt be your new Diviſor; and upon enquiring how often this new Diviſor is contained in your new Reſolvend (excepting always the two laſt Figures) you will find it to be three Times; ſet then 3 in the Quotient, and proceed to find a new Subſtrahend, in the ſame Manner as we have already directed, and which you muſt repeat as often as a new Figure is to be ſet in the Quotient: This will be found to be 2639007, which being ſubſtracted from the Reſolvend, you will have no Remainder, as will appear by the Work itſelf; the whole Proceſs of which is as follows;

160|103|007 (543 Root.
125

75) 35103 Reſolvend.
32464 Subſtrahend.

8748)2639,007 Second Reſolvend.
2639,007 Second Subſtrahend.
0000 000

5
4
20 4
3 16
60

5
5
25
3
75 . . Triple Squared
60 . Quotient.
16
8116
4
32464

54

54		54
3		54
162	3	216
3	3	270
486	9	2916
		3
		8748.. Triple Squared
		486. Quotient.
		9
		879669
		3
		2639007

Obſerve here that the above Number being a perfect Cube its Root is exactly 543; but in caſe you ſhould (as it often happens) be obliged to extract the Cube Root from an Irrational or Surd, or a Number that is not a complete Cube, you may approach it as near as poſſible by adding Ternaries of Cyphers to the ſaid Surd Number; and when the Cube Root of it and the additional Cyphers is extracted, you will have the Roots and Decimal Parts near enough for any Buſineſs; as may be ſeen by the following Example:

37|864|125|,000(335,7			
27	3	33	335 335
—	3	33	335 7
10864	—	—	— —
8937	9	99	1675 2345
— —	3	99	1005 3
1927125	—	—	1005 —
1658375	27..	1089	— 7035
— —	27.	3	112225
268750,000	9	—	3
236165 293	—	3267..	— —
— — —	2979	495.	336675..
32584 707	3	25	7035.
	—	—	49
	8937	331675	— —
		5	33737899
		—	7
		1658375	— —
			236165293

Thus the Cube Root of the above Number is found to be 335,7, and a large Remainder: Now to prove the Work; cube the ſaid Cube

Root, and to the Cube of it add the Remainder, and if the Work is right, the Sum or Aggregate will be equal to the Sum from whence the Root was extracted; as for Example:

```
        3357
        3357
       -----
       23499
      16785
     10071
    10071
   --------
    11269449
        3357
   --------
     78886143
    56347245
   33808347
  33808347
  ----------
  37831540293 Cube.
     32584707 Remainder.
  ----------------------
  37864125000 Sum or Aggregate from which the
                Root was extracted.
```

Now as it will often happen (as I have already ſaid) that you muſt extract the Cube Root from ſome given Number that will not anſwer exactly; I have (to prevent your throwing away time) thought proper to give you ſome Rules, by means of which you may readily know all thoſe Numbers that will not anſwer exactly to a Cubical Extraction.

1. All Numbers ending with two or more Cyphers, and which cannot be meaſured by the Ternary Number, that is, that cannot be exactly divided by three, cannot have their Roots perfectly Cubical, ſuch as theſe, 3400, 62800, 453000.

2. All Numbers ending with 2, or 4, and whoſe laſt Figure but one is even, cannot be exactly Cubic, ſuch as, 3522, 62864.

3. Every Number ending with 4 or 8, and whoſe laſt Figure but one is not a Cypher or an even Number, cannot be punctually Cubic; as for Example; 456174, 110038.

4. Such Numbers as cannot be exactly divided by 9, are never perfectly Cubic; therefore the following Number 12000 is not ſo; for it being divided by 9, you will have a Remainder of 3.

Let this little that we have now ſaid concerning the Extraction of the Cube Root, and a Knowledge of the Cubic Numbers, ſatisfy you for the preſent; the Uſe of it ſhall be evidently explain'd in the Sequel of our Practice, and ſubſequent Operations.

Now

Now if you would make a Table of Cubes with their Roots from Unity, or the Diameter of one Pound, *ad infinitum*; you may firſt aſſume any Number that you ſhall think fit to ſerve as a Root, which being multiplied cubically by itſelf, will produce the firſt cubical Number; and its Root, or the Number you ſhall have aſſumed for its Cube Root, muſt be firſt ſet down in this Table. As for Example; if you take the Number 100 for a Root, and it be multiplied cubically into itſelf, your firſt Cube will be 1,000,000, of which 100 being the Root, it muſt be ſet down in your Table as the firſt Root.

If you would extract the Cube Root from double this Cube; you muſt double it, and you will have 2,000,000, from whence, if you extract the Cube Root, you will find it to be 125, which will be the ſecond Root of your Table, and the ſecond Number. If you would know the Root of this Cube when trebled, quadrupled, and ſo on; firſt, treble or quadruple it, or increaſe it, *ad Infinitum*, and from thoſe Numbers (as you go along) extract the Cube Roots, and place them in a regular Order in your Table; joining in a Column upon one Side of them, the aſcending or increaſing Numbers in a natural Order, from Unity as far as you pleaſe. This is the Method I obſerved in the Conſtruction of the following *Table*, the Aſſiſtance of which, if you pleaſe to accept, in forming the *Calibre Scale*, I muſt tell you; that it is firſt neceſſary that you ſhould have the Diameter of a Bullet of one Pound, made of the ſame Metal with thoſe Bullets which you would form your *Calibre Scale* to meaſure. For Example; if you would prepare an Inſtrument or *Calibre Scale*, to calibre Iron Bullets; divide the Diameter of an Iron Bullet of one Pound, actually taken from an Iron Bullet of that weight (I ſhall, in the Sequel, ſhow how that is to be done) into as many equal Parts, as the firſt Root of the *Table* contains Unities; as here, in our *Table*, the firſt Root contains 100 Unities; therefore divide the Diameter of an Iron Bullet of one Pound, into an hundred equal Parts, which you may readily perform by the Help of the Parallelogram, or Diagonal Scale, *Fig.* 1. Having then with a Pair of Compaſſes taken from that Scale all the Parts, according as they are expreſſed in the *Table* of Cube Roots; tranſpoſe the Diameters of your Bullets upon the *Calibre Scale:* As thus; if you take 100 for the Diameter of an Iron Bullet of one Pound, you muſt allow 125 of the ſame Parts for the Diameter of a Bullet of two Pounds; that is, you muſt add 25 Parts to the firſt Diameter. Again, for the Diameter of a Bullet of three Pound, you muſt take 144 Parts, or add 44 Parts to the firſt Diameter; and in the ſame manner you may tranſpoſe the Diameters of all other Bullets upon the *Calibre Scale.* This gradual Increaſe of the Diameters and their reſpective Circumferences in the *Ratio* of Solids, is very plain, and to be eaſily conceived by *Fig.* 2, in which the firſt Circle denotes the Circumference of a Bullet, whoſe Diameter is as the firſt Root, and its ſolid Contents as the firſt Cube.

The

The ſecond Circle is the Circumference of a Bullet whoſe Diameter is as the ſecond Root, and its Solidity of double the firſt Cube. In the ſame manner you are to infer, with regard to the other Circumferences in the ſame *Fig.* as to their Diameters and Solid Contents.

Whatever we have here ſaid of Iron Bullets, may be ſaid of thoſe alſo that are made of Lead, Stone, *&c.* which may be calibred by the very ſame Rules; ſo that you may, with equal Eaſe, conſtruct a *Calibre Scale* for that Purpoſe.

We have given you a Repreſentation of this Inſtrument in *Fig.* 3. upon one of whoſe Surfaces you will ſee the Diameters of Iron Bullets accurately marked out, and upon the other the Diameters of Leaden Balls.

A Table of Cubes and Cube Roots in a natural Order from Unity upwards----- the firſt Cube being ſuppoſed to contain 1,000,000 *of Parts.*

Order of the Cubes.	Roots.	Order of the Cubes.	Roots.	Order of the Cubes.	Roots.	Order of the Cubes.	Roots.
1	100	26	296	51	371	76	424
2	125	27	300	52	373	77	425
3	144	28	304	53	376	78	427
4	159	29	307	54	378	79	429
5	171	30	311	55	380	80	431
6	182	31	314	56	382	81	433
7	191	32	317	57	385	82	434
8	200	33	321	58	387	83	436
9	208	34	324	59	389	84	438
10	215	35	327	60	391	85	440
11	222	36	330	61	394	86	441
12	229	37	333	62	396	87	443
13	235	38	336	63	398	88	445
14	241	39	339	64	400	89	446
15	247	40	342	65	402	90	448
16	252	41	345	66	404	91	450
17	257	42	348	67	406	92	451
18	262	43	350	68	408	93	453
19	267	44	353	69	410	94	455
20	271	45	356	70	412	95	456
21	276	46	358	71	414	96	458
22	280	47	361	72	416	97	459
23	284	48	363	73	418	98	461
24	288	49	366	74	420	99	463
25	292	50	368	75	422	100	464

CHAP.

CHAP. II.

The Geometrical Conſtruction of the Calibre Scale.

IT is abſolutely neceſſary that you ſhould have the Side of the firſt Cube, or the Diameter of a Bullet of one Pound, made of the ſame Metal, for the particular Uſe of which you would conſtruct your *Calibre Scale.* For Example; in *Fig.* 4, let there be given the Line A, B, for the Diameter of an Iron Bullet of one Pound; then, in order to find the Side of double the Cube, that is, the Diameter of a Bullet of two Pounds, double the Line A, B, or extend it to twice its Length, which ſuppoſe to be the Line A, D; then find out two mean Proportionals between the ſingle Line A, B, and the double Line A, D, and there will be one of them found *(viz.)* the leaſt of the two mean Proportionals, which is D, E, which will be the Side of the double Cube, or the Diameter of an Iron Bullet of two Pounds; in this manner you muſt proceed to find out the Diameters of all other Bullets, that is, by increaſing the Length of your Firſt Diameter as far as is proper or requiſite, and then finding out two mean Proportionals between the Line expreſſing the Length of your firſt Diameter, and the increaſed Line.

The moſt experienced Geometricians, however, aſſure us, that never any one yet hath invented the true Method of finding out two mean Proportionals Geometrically, between two other given ones; notwithſtanding that many of them have greatly labour'd, and employ'd much of their Time in ſearch of this Secret: The thing, indeed, is extremely difficult, inaſmuch as we can produce no *Ratio* (I mean, that is truly Geometrical) to double, treble, *&c.* or encreaſe a Cube, *ad Infinitum*, by means of a common Scale and Compaſs only, as is uſually done, when we would augment the Proportion of any kind of Planes; which, however, cannot poſſibly be done, 'till you have previouſly found out two mean Proportionals by a nice Reſearch.

A vaſt many Geometricians, as well ancient as modern, have done their utmoſt to ſolve this very authentick Problem, which indeed is of the greateſt Uſe in all mechanical Matters; and have even endeavoured to demonſtrate it, as a Plane and Linear Figure (though there are thoſe who place this in the Rank of Problems relating to Solids) by certain mixed Lines artfully drawn, and by ſimple Lines immediately proceeding from a Plane, as are all Right Lines and Curves. Amongſt which *Nicomedes* has endeavour'd to demonſtrate it by a Conchile Line, *Diocleſian* by a Coſſoidea or Hederacea, *Menechnus* by Conic Sections, and many others by the Parabola; but *Eratoſthenes*, *Sporus*, and *Plato*, have aimed at it by Right Lines and Curves; and even *Pappus*, *Hero*, *Apol-*

Ionius, Pergæus, Philo Biſantius, Orontius, Villalpandus, Clavius, and many other Geometricians, have laboured to do it by ſeveral other Methods: But whatever they have ſaid or done upon this Head; I think it unbecoming of me to examine too ſcrupulouſly into the Works of thoſe illuſtrious Men, to whom the Republick of Learning is ſo greatly indebted; and much leſs would it become me to paſs a Judgment upon them, or to determine too raſhly concerning their Thoughts upon this Subject. I ſhall only ſay, that it is acknowledged and declared by the greateſt Geometricians, that it is impoſſible to increaſe the Cube by Planes; and this I affirm from the very Confeſſion of thoſe who have ſo cloſely ſought after it. But this is not ſufficient for us to condemn their Inventions, reject their laborious Efforts, or look upon them as repugnant to right Reaſon and Truth: No; on the contrary we ought to continue the Uſe of them, until a more happy Age ſhall produce ſuch as are preferable and more perfect. In ſuch a variety of Practice as has been uſed to this End; I have pitched upon one Method only, which I here preſent for your Uſe in increaſing the Cube, and to find out two mean Proportionals in a continued Order, and which, I believe, will be ſufficient, in the right and proper treating of Pyrotechnical Matters.

Let there then be found two mean Proportionals in a continued Order, between the two above-mentioned Lines A, B, and A, D; let them be firſt placed at right Angles to one another, and let the Parallelogram A, B, C, D, be conſtituted upon them, and let A, B, and A, D, be continued *ad Infinitum*; then the Diagonals B, D, and A, C, being drawn, let H be placed at the Interſection of them; and apply a Ruler to the Point C, which will cut the Lines A, B, and A, D, continued *ad Infinitum*, in the Points E, and F, in ſuch a manner that H, E, and H, F, may be found equal: This done you will have D, E, and B, F, for mean Proportionals continued between the given Lines A, B, and A, D; for they will be as C, D, that is, as A, B, is to D, E, and as B, C, that is, as A, D, to B, F.

I purpoſely omit the other Methods, the greateſt Part of which you may find, as well in the Authors above quoted, as in *Marius Bottinus*'s Treaſury of *Mathematical Philoſophy*, lately publiſhed at *Bologna*, wherein he endeavours, by all Means, to prove, that the ancient Geometricians, as well as ſome of the moſt modern (whoſe Names he mentions) have not only diſcovered the true, plain, and perfect Method of finding out two mean Proportionals to any two given; but that they have alſo illuſtrated it by Geometrical Demonſtrations; ſo that nothing can be further deſired upon this Head. But let us attend to what he ſays in this Tranſlation of a Paſſage in his *Latin* Treatiſe, *(viz.) Therefore what we have formerly ſaid in* Apiar. III. Prob. I. *in relation to the Conchoid of* Nicomedes, *in a doubtful and cautious manner, we do now boldly affirm (in order to ſhew that the beſt Part of the Geometrical Philoſophy, concern-*

ing Solids, is truly eſtabliſhed) that two mean Proportionals have been long ago Geometrically and Demonſtratively found. For to ſay nothing of the Inventions of the reſt of the Ancients, *and only mention one, of which there are Footſteps ſtill remaining amongſt us; the two mean Proportionals found by* Nicomedes *by help of the Conchile Line have that Geometrical Certainty, than which no greater can be deſired, in the Geometrical Demonſtration of any Problem* —— And a little lower —— *Upon which Account there remains no Reaſon to doubt, but that the Geometrical Method of finding two mean Proportionals was invented long ago, as likewiſe that the Truth and Certainty of all Stereometrical Problems ariſing from two Proportionals are Geometrically demonſtrated.*

But we have found an eaſy Contrivance by means of Inſtruments, whereby to find not only two mean Proportionals to two others given, but in any Number of Proportionals required; and by that Invention we may be able at laſt to reduce a given Solid to a Cube, contain'd within Æquidiſtant Lines, as alſo to change one Figure into another Equal to it or bigger, ſtill keeping its Likeneſs; wherefore it is not to be doubted but Altars *and* Edifices *may be doubled by ſuch an Inſtrument, and alſo one may refer to the Cube the Meaſures of Dry and Liquid Subſtances, as of Buſhels,* &c. *The Contents of which Meaſures are known by the Sides of the Veſſels, and in a Word, the Knowledge of this Queſtion is uſeful to thoſe, who would make bigger Sorts of ſuch Machines as are uſed for throwing of* Darts, Stones, *or* Iron Balls; *for in thoſe Caſes, it is neceſſary that all the parts of the Machine ſhould be encreaſed in a certain Proportion, as well as the Things to be thrown, and this cannot be done without the Invention of a mean Proportional.*

CHAP. III.

The Mechanical Conſtruction of the Calibre Scale.

OF ſo great a Number of *Pyrotechnicians*, or Artificial Fireworkers that we ſee in our Days, we ſhall not find one (pardon me for the Expreſſion) that does not deſire the good Opinion of the World, and to be eſteemed a good Practitioner: But at the ſame time they chooſe to be ſuch in Appearance, rather than in Reality; and only outwardly affect to appear very knowing in their Profeſſion: Though by the way a thorough Knowledge in it is not to be acquired in peaceable Times, in the Chimney Corner, amidſt the ſoftening Effeminacies of the Body, Serenity of the Mind, or by ignoble Sloth; but on the contrary by the inſupportable Fatigues of the Field, at the imminent Danger of Life, and the Sweat of the Brow. I have even known ſome of them who ſcorning the plain and vulgar Denomination of *Pyrotechnicians*; but glorying

rying in the Title of Fire Engineers in the Military Capacity, which the *Flemmings* call *Feld-Fewerwercker*, have thought it beneath them (they being deſtitute of Theoretical Principles) to concern themſelves with any of the Theorems of *Archimedes* or *Euclid*, or any other famous Author, or even to produce any Demonſtrations to prove and confirm the Rules of their Art. Hence comes this new Pſeudomechanical Science entirely unknown to the greateſt part of paſt Ages, and whoſe chief and moſt general Axiom is, *Perturbare confuse & nihil ad rem omnia agere*; that is, to put every thing into the utmoſt Confuſion, and never do any thing as it ſhould be. Conſider now, whether the Burthen of this Self-ſufficient Mother can be ſucceſsful? Or whether the Fruit of ſuch a Science muſt not be ſtrangely uncouth? Every Day you have irreparable Errours and Defects, as well in the Conſtruction of Warlike Machines, as in the Preparation and artful Management, or handling of them. The *Fireworks* on ſerious and neceſſary Occaſions, as well as thoſe exhibited upon Publick Rejoicings, are for the moſt part prejudicial to the Prince, and evidently dangerous to the Lives of thoſe who work in the Compoſition of them, as well as to thoſe of the Spectators who behold them. How greatly are thoſe to be pitied, who are ignorant in the Principles of true Mathematicks! Hear what * *Paulus Guldenus* ſaith, in an Arithmetical Problem, where he ſpeaks to this Effect in his *Latin* Treatiſe. *Leaſt therefore our* Mathematicians *ſhouldb ecome unworthy of that Title; but that on the contrary, they may lift up their Heads out of the Ocean of Ignorance, and apply themſelves to the Study of the moſt noble of thoſe Sciences; we have in the beginning of our Lectures, looked upon the* Mathematicks *as a moſt powerful Queen with her numerous Houſhold of ſubject Sciences; whoſe Order, Subdiviſions, Definitions, with their Differences and Diſtinctions, we have fully and clearly explained in our Lectures; and in order to imprint them the more ſtrongly in the Memory, we have in a very agreeable pleaſing Method collected them upon a ſmall Sheet of Paper, not for the Uſe of our Times only, but as an acceptable Preſent to Poſterity likewiſe. We have laid down* Arithmetick *and* Euclid's Geometry *as the Baſis or Foundation, of the Mathematical Superſtructure; without which it is impoſſible for any one, though he were to live and ſtudy to the Age of* Neſtor, *to attain any true and ſolid Knowledge in that Science. From a Want of thoſe firſt Rudiments proceed that Obſcurity and Chimerical Uncertainty, that Labyrinth of Errours, and that vaſt Chaos of Ignorance. Hence it is, that Men are ſo far miſtaken as to be ignorant of what they do know, and think they know what they are ignorant in. Hence ſo many Mechanical Mathematicians, unskilful Surveyors, ſo many Exhauſters of Wine Casks, inſtead of Gaugers: Hence ſo many Bankrupt Merchants, unfortunate Captains in War, falſe Architects, and Artificers, who rather promiſe to conſtruct new Machines for great Purpoſes, ſuch as*

* Paulus Guldenus Lib. IV. Centro, Cap. v.

raiſing

raiſing Water to great Heights, and for removing vaſt Bodies, than perfect them. Hence ſo many Engineers without Ingenuity, diſappointed Searchers after the perpetual Motion, ſo many unhappy Squarers of the Circle, and all the Blunders of Architects. In fine, hence the Man that begins to build, and knows not how to finiſh or compleat what he has begun. But I would by no means have it thought, by what I have here ſaid, that I would in the leaſt depreciate the Military Practice, to which alone I more particularly applied myſelf: I am only grieved to ſee this illuſtrious Science of *Pyrotechnicks* diſhonoured even by thoſe who profeſs it; (I mean Practitioners without Foundation;) who have deſpoiled it of its ancient Glory, and ſtripped it of all its moſt beautiful Ornaments, beſtowed on it by its firſt Inventors; and ſtill keep it ſeparated, and as it were, forcibly torn from the Boſom of its lawful Mother the *Mathematicks*, as a Science alien to and independent of it; and have crowded it in amongſt the moſt illiberal Arts, and the moſt Mechanical Operations.

In Truth, I could wiſh, that entirely baniſhing this new Mechanical Science; I ſay, I could wiſh, that no one would by any means ſuffer a Novice or Apprentice to take any Work in hand, till he is firſt well grounded in the Principles of *Arithmetick* and *Geometry*; from whence we might expect, that this great Art would, in a little time, retrieve its Original Luſtre; and conſequently that the Invention of ſo many ridiculous (I ſhould chooſe to ſay, coſtly and dangerous) Machines, which thoſe Maſter Workmen have exhibited, would be juſtly exploded, and we might at leiſure taſte the delicious Fruits of this Science.

But let us reſume the thread of our Subject, and ſince we have engaged ourſelves to give in this Chapter the Methods of Conſtructing the *Calibre Scale* mechanically; you muſt firſt know, that there is nothing ſo eaſy as all theſe Inventions; but if you would at any time try, whether or no they can bear the Teſt of Geometrical Proportion, which is the true Touchſtone of all ſuch things, you will infallibly find them incumbered with Falſities and Errours, and will perceive that it is entirely impoſſible to demonſtrate them according to the Rules of Art. We muſt own however, that ſome of them have been found to be right; but they have not yet been demonſtrated Geometrically; all the reſt are falſe, or at leaſt doubtful; which we are nevertheleſs obliged to bear with patiently, becauſe they do not ſeem repugnant to common Senſe. For my part, I never commended or approved of them, inaſmuch as I never acknowledged them to be grounded upon the leaſt Foundation of Geometrical Truth. Now this Art conſiſts in one Point, from whence if you deviate to the Right Hand, or Left, forwards, or backwards, whether you carry the Foot all round the Circumference or not, you will find your Operations defective, and yourſelf far enough off from what you ſought. Therefore I cannot adviſe any Body, to make uſe of this Method. However, that I may not conceal any Article from the Reader, who is deſirous of knowing every thing, I ſhall diſplay the

Practice which thoſe Artiſts we have been ſpeaking of, value at ſo high a Rate: But I ſhall here dwell upon two Examples of it only, which ſeem to me the moſt Geometrically proportionate, and better founded than the reſt.

EXAMPLE I.

The Perpendicular, C, K, being drawn *ad infinitum*; from the Point C towards K; in B let the Diameter of a Bullet of one Pound C, B, be placed; then from the Center A, deſcribe the Circle B, D, E, C; and let the Diameter B, C, be divided into three equal Parts, C, I; I, H; and H, B; and let a third be ſet off upon the Periphery of the Circle from B to F, and from F to E upon one Side of the Diameter, and on the other Side from the ſame Point B to G, and from G to D. Now, if from C you draw through the Points D, and E, the right Lines C, L, and C, M, *ad infinitum*, you will have your Figure adjuſted; by which you muſt increaſe the firſt Cube, or the firſt Diameter of a Bullet after this manner. Having taken the Diameter C, B; from C ſweep the Segment of a Circle 1. 1. then taking the diſtance between the Points 1. 1. from the ſame Point C deſcribe the Arch or Segment 2. 2. and the diſtance of the Points 2. 2. from the Point C upon all the three Lines, will be the Side of the double Cube, or the Diameter of a Bullet of 2 Pounds. Again, take the tranſverſal Diſtance of the Points 2. and 1. which is marked with a prickt Line, and deſcribe the Arch 3. 3. and the diſtance between the Point C, and the Points 3 upon each of the three Lines will be the Diameter of a Bullet of three Pounds. In like manner take the diſtance of the Points 2. 2. upon the Lines C, M, and C, L, and from C deſcribe the Segment 4. 4. and the diſtance between the Points marked with 4 and the Point C will be the Diameter of a Bullet of four Pounds. This Method you muſt purſue in finding out the Diameters of other Bullets: that is, by adding always the leſſer uneven Number, to the greater even one, and reciprocally the leſſer even Number to the greater uneven one; or by taking the tranſverſal Lines drawn betwixt them; and alternately as you go along taking the Lines directly extending from one and the ſame Number, as may be ſeen in *Fig.* 5. where we have carried on the Progreſſion to the Number 20; but as this is ſelf-evident, it would be Time ill ſpent to ſay any more of it.

EXAMPLE II.

Let the Diameter of a Bullet of one Pound be divided into 4 equal Parts, and let $\frac{1}{4}$ be added to the firſt Diameter, and you will have the Diameter of a Bullet of 2 Pounds; then divide the Diameter of a Bullet of 2 Pounds into 7 equal Parts, and add $\frac{1}{7}$ to the Diameter of a Bullet of 2 Pounds, and you will have the Diameter of a 3 Pounder. And

in this Manner and Proportion, you muſt increaſe the Number immediately preceding, to find the Diameters of all other Bullets: Thus you may continue it to what Number you pleaſe. As for me, I have carried it on no further than the Number 10, to ſave my Time and Labour; but I have continued it in another Method to 100, aſcending decimally by 10 and 10 at a time, and always dividing by 4, as will be plainly ſhewn by the following Table. As to the Numbers between each 10, you are to proceed with them in the ſame manner as you did with the firſt 9 Numbers. Moreover if you divide the Hundreds in the ſame manner, you will have the Hundredths in the ſame Proportion as the Decimals and Unities.

Diameters of Bullets.	Divided into Parts.	Parts added to the Diameters.	Make the Diameters of Bullets weighing lb.
1	4	$\frac{1}{4}$	2
2	7	$\frac{1}{7}$	3
3	10	$\frac{1}{10}$	4
4	13	$\frac{1}{13}$	5
5	16	$\frac{1}{16}$	6
6	19	$\frac{1}{19}$	7
7	22	$\frac{1}{22}$	8
8	25	$\frac{1}{25}$	9
9	28	$\frac{1}{28}$	10
10	4	$\frac{1}{4}$	20
20	4	$\frac{1}{4}$	30
30	4	$\frac{1}{4}$	40
40	4	$\frac{1}{4}$	50
50	4	$\frac{1}{4}$	60
60	4	$\frac{1}{4}$	70
70	4	$\frac{1}{4}$	80
80	4	$\frac{1}{4}$	90
90	4	$\frac{1}{4}$	100
100	4	$\frac{1}{4}$	200

We have call'd theſe two above given Examples Mechanical; becauſe they are neither demonſtrable nor artificial; they may, however, in ſome reſpect be called Geometrical; by reaſon of the great Reſemblance they have to Geometrical Problems, that are perform'd with Inſtruments; but nevertheleſs, theſe are not purely Geometrical, though they may, in ſome ſort, be called Mathematical; they may, at leaſt, be ranked amongſt thoſe that are worked by Scale and Compaſs only; thoſe two Inſtruments being immediately founded upon the *Poſtulata*, that is, upon the Right Line and the Circle; the ſame may be ſaid of all thoſe Inſtruments that are made by Scale and Compaſs; but in the main they are merely Mechanical.

APPENDIX.

A certain eaſy Method of Conſtructing the Calibre Scale.

NOtwithſtanding that the two Methods we have already given (not reckoning the Mechanical one) have nothing difficult attending them, it being by them plainly demonſtrated, that the firſt and fundamental Origin of our *Scale* is drawn from Axioms, and the moſt certain Truths of Arithmetick and Geometry; yet as they are a little perplexed and diſagreeable, becauſe of the Extraction of the Cube Root, and the Neceſſity of finding out two mean Proportionals; I cannot preſent you with a more eaſy Direction, than by recommending the Sector to you, provided it be faithfully adjuſted; for as upon that Inſtrument you have the Stereometric Line, exactly divided into Sides of Cubes, or rather the Diameters of Bullets, it is derived from Arithmetical Calculation. Therefore having, with a Pair of common Compaſſes, taken the Diameter of a Bullet of one Pound, made of any Metal whatſoever, let it be apply'd tranſverſally upon the Cubical Line from 1. to 1. and thus, without removing the Inſtrument from its Poſition, take in like manner the Diameters of all other Balls or Bullets, and tranſpoſe them upon the *Calibre Scale*; by this means you will have your Scale conſtructed by once opening the Sector: (See *Fig.* 8.) But if you have not the Convenience of a Sector, you may, inſtead of that, make Uſe of *Fig.* 7, with regard to which you may proceed after the following Manner.

Let the Line A, B, be drawn *ad Infinitum*, upon which, from the Point A towards B, ſet off the Sides of all the Cubes taken from our Table of Cube Roots in *Chap.* I. which you may do by any Scale you pleaſe, from Unity to what Number you think fit. Then take the Diameter of a Bullet of one Pound, made of the ſame Metal with thoſe Bullets you intend to meaſure; and fixing one Foot of the Compaſs at the Point 1. deſcribe an Arch or Segment of a Circle with the other, and let its Tangent A, C, be continued *ad Infinitum.* The Diſtance between the Diviſions of the Line A, B, and the Tangent, will be the Diameters of Bullets *ad Infinitum*, increaſing continually according to the Progreſſion of Numbers, following one another in a natural Order, and ſucceſſively exceeding one another by one Pound Weight at a time.

CHAP.

CHAP. IV.

A Method to find and tranſpoſe, or ſet off the Diameters of Bullets upon the Calibre Scale, whoſe Weights are leſs than one Pound, the Diameter of a Bullet of one Pound being firſt given.

SUPPOSE then that the Diameter of a Bullet of one Pound (as we have already obſerv'd in a foregoing Chapter) be divided into 100 Parts; let it be cubed, and you will have 1,000,000, divide this by 32, (which is the Number of *Loths*, or half Ounces in a Pound) and you will have 31250 in the Quotient, from which, if you extract the Cube Root, it will be found to be 31. Take off then with your Compaſſes that Number of Parts from the Scale above-mentioned *Fig.* 1. and ſet them upon your *Calibre Scale* from A to B, and you will have the Diameter of a Bullet of one *Loth*, or half an Ounce. Now, in order to find the Diameters of Bullets, whoſe Weight conſiſts of ſeveral *Loths*, or half Ounces, you need only double, treble, *&c.* the Cube of the Diameter 31, which was laſt found, and then extract the Cube Roots of your increaſed Numbers, in the ſame manner as was done to find out the Diameters of Bullets weighing ſeveral Pounds. This is the Method I followed in the compoſing of the following Table, from whence you may take the Diameters of half Ounces and tranſpoſe them upon your *Calibre Scale*, by the help of the Diagonal Scale beforementioned. Furthermore, if you would have the Diameters of the Aliquot Parts of an half Ounce (*viz.*) the $\frac{1}{2}$ the $\frac{1}{4}$ the $\frac{1}{8}$ the $\frac{1}{16}$, divide the Cube 31 by 2, 4, 8, 16, and extract the Cube Root from the Quotient of each Diviſion, and you will have the Diameters of the Aliquot Parts of an half Ounce, as may be ſeen by the following Table.

Order of the Cubes.	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	1	2	3	4	5	6	7	8	10	12	16	18	20	24	30
Roots.	12	15	19	24	31	39	44	49	53	56	59	61	66	70	78	81	84	89	96	

ANOTHER METHOD.

Take the Diameter of a Bullet of 2 Pounds, and divide the ſame into 4 Parts, and $\frac{1}{4}$ will be the Diameter of a Bullet of half an Ounce; take

again the Diameter of a Bullet of 4 Pound, and divide it into 4 Parts, and $\frac{1}{4}$ will be the Diameter of a Bullet of an Ounce. Thus you may go on with encreaſing your Diameters 2 Pound at a time, and dividing them into 4 equal Parts, and $\frac{1}{4}$ will be the Diameters of Bullets, encreaſing half an Ounce each time in weight.

Thus you may continue till you come to 64 Pound, for the $\frac{1}{4}$ of the Diameter of a Bullet of that weight is exactly the Diameter of a Bullet of one Pound.

If you would work this by the Compaſs of Proportion or Sector, tranſpoſe the Diameter of one Pound, taken with the common Compaſſes, tranſverſly upon the Line of Cubes, (or, which is the ſame thing, upon the Line of Solids) between 32 and 32, and without altering the Inſtrument, add together all the tranſverſal Diſtances between 1 and 1, 2 and 2, 3 and 3, and ſo on to 31, and you will have the Diameters of Bullets of all the half Ounces contained in a Pound. If you do not make uſe of the Sector, the *Fig.* 7. I gave you in the foregoing Chapter will ſerve your Purpoſe, provided that by means of any Scale of equal Parts you ſet off upon the bottom Line 32 Stereometrical Spaces from A towards B, each diſtinguiſhed with Points and Numbers; and if you go on ſtill farther, you muſt take care to carry on your Operation in the Method I have already laid down.

CHAP. V.

A Method to find the Diameter of a Bullet of one Pound by the Diameter of another Bullet weighing ſeveral Pounds.

ARITHMETICALLY.

THE Method we ſhall take in this Operation will differ but little from what we have ſaid in the foregoing Chapter, except that the Diameter of the given Bullet may be divided into a certain Number of Parts, as for Example into 100, 200, 300, or elſe into 10, 20, 30, *&c.* more or leſs, but you will work upon a more certain Foundation the larger the Number it is divided into. You need not here ſtick to the Obſervance of the 100 Parts of the Diameter of one Pound, as we have already divided it, which you will perceive by what follows. Suppoſe now for Example you have an Iron Bullet, or one made of any other Metal, of any Size and Weight whatever; and ſuppoſe you would by Means of this, know the Diameter of a Bullet of one Pound, made of the ſame Metal with itſelf. In *Fig.* 8. let A, C, be the Diameter of an Iron Bullet A, B, C, D, (which you may take with two ſmall gnomonical Inſtruments, elevated upon any Plane, or with the

Calibre Compaſſes, *&c.)* divide then the Diameter into a certain Number of equal Parts; let us divide it in this Example into 100 equal Parts, as we have elſewhere done with regard to the Diameter of a Bullet of one Pound; this done, divide the Cube of 100 by the Weight of the Bullet: Set the Caſe that the Ball be a 24 Pounder; you muſt divide the Cube of 100 by 24, and extract the Cube Root from the Quotient of your Diviſion, and you will have the Number of Parts which conſtitute the Diameter of a Bullet of one Pound, as may be ſeen by the following Operation:

℔	Cube.			
24)	1,000,000	(41,666	(34 Root	3 3
	96	27 .		4 3
	.40	14666		12 9
	24	12304		3 3
	160	2362 Remainder.		36 27 . .
	144			360
	.160			16
	144			3076
	.160			4
	144			12304
	16.			

Obſerve here that if from the Diameter of a given Bullet, you would know the Diameter of a 2 Pounder, you muſt divide the Cube of the Diametrical Parts by half the Weight of the given Bullet; again, if you would have the Diameter of a 3 Pound Ball, you muſt divide by $\frac{1}{3}$) of the Weight of the given Bullet; in ſhort, if you would from this likewiſe have the Diameter of a 4 Pound Ball, you muſt divide the Cube of the Number of Parts, into which the Diameter of the given Ball is divided by $\frac{1}{4}$, of its Weight; which done, extract the Cube Roots from your Quotients, and you will have what you required.

GEOMETRICALLY.

Let the right Line A, B, *Fig.* 9. be drawn *ad infinitum*, and upon the Point A, let fall the perpendicular A, C, upon which ſet off the Diameter of the given Bullet from A to D; at the ſame time it is neceſſary that you ſhould know the Weight of the given Bullet, which if it does not exceed 8 Pounds, divide the Diameter into two equal Parts, and then ſubdivide the upper Section into 100 equal Parts: But if the Ball exceeds the Weight of 8 Pounds, you muſt divide the Diameters of all

Bullets

Bullets between 8 and 27 into 3 equal Parts, obſerving to ſubdivide the uppermoſt third, into 100 equal Parts as before. Again, if the Weight of the Bullet exceeds 27 Pounds, you muſt divide the Diameters of all Bullets between the laſt mentioned Number and 64 into 4 equal Parts; if it exceeds 64 into 5, if 125 into 6, and if 216 into 7. And thus you muſt do ſucceſſively whenever the Weight of a Bullet exceeds any cubical Number; that is, you muſt divide its Diameter into as many equal Parts as the Root of the ſubſequent Cube contains Unities, and always ſubdivide the uppermoſt Section into 100 ſmaller Parts. This being ſuppoſed, let the right Line F, G, be drawn parallel to the Baſe from I, that cuts off the lower Diviſion of the Line A, D, and then look for the Cube Root inſerted over-againſt the Weight of the Ball in the Stereometric Table, which having found, take the Diameter of it with a pair of Compaſſes. It being very evident, that each of the Sections into which the whole Diameter is divided, contains 100 Parts equal to thoſe into which the upper Section is ſubdivided, inaſmuch as they three are all equal within themſelves; it will follow, that you muſt reckon from A towards C as many Parts as the Number in the Table of Cube Roots over-againſt the Weight of your Bullet contains Unities. Then fixing one of the Feet of your Compaſſes at the Point of the Number found, with the other deſcribe an Arch of a Circle, interſecting the Baſe of the *Figure*; and from the Point of Interſection draw a right Line to the Point of the Number found, which muſt neceſſarily cut the Line F, G, parallel to the Baſe; then take the diſtance between the Points of one and the other Interſection; that is, from the Baſe to the other Line that is parallel to it, and you will have what you required.

In *Fig.* 9. Let A, D, be the Diameter of a Bullet of 10 Pounds: Now becauſe this exceeds the Weight of a Bullet of 8 Pounds, its Diameter is divided into 3 equal Parts, which are A, F, F, K, and K, D, and its upper Section is ſubdivided into 100 equal Parts. From the Point F which interſects the lower Third of the Diameter, draw the Line F, G, parallel to the Baſe A, B; this done, look for the Number in the Table of Cube Roots that is over-againſt 10, the Weight of your Bullet, and you will find it to be 215. Suppoſing now that A, F, and F, K, contain each 100 Parts; if you reckon 215 Parts from A, towards C, you will find the Point L, from whence if an Arch of a Circle be deſcribed whoſe Semi-Diameter is equal to the Diameter of the given Bullet, it will interſect the Baſe A, B, in the Point H; and a right Line being produced from H, to L, it will in like manner interſect the Line F, G, in the Point I, and thus the diſtance between the Points H and I, is the Diameter of an Iron Bullet of one Pound, which was required.

Obſerve here that if the Weight of the given Bullet anſwers exactly to a Cubical Number, you muſt in that Caſe divide its Diameter into as many firſt and principal Parts, as the Root of it contains Unities; for one of the Parts of a Diameter thus divided will be the Diameter of a

Bullet

Bullet of one Pound: But all this being extreamly eaſy, it needs no further Illuſtration.

This may be performed with much more readineſs with the Sector, by putting the Diameter of the given Bullet between the Points and Numbers that expreſs the Weight of it upon the Stereometrical Line, and then upon the ſame Line taking the diſtance between the Points 1 and 1, which diſtance will be the Diameter of a Bullet of one Pound.

With the ſame eaſe and to the ſame purpoſe you may uſe the *Fig.* 7. deſcribed in the third Chapter, if you rightly conceive how to put it in practice.

CHAP. VI.

A Method to find the Solidity of all ſorts of Bullets, whether in Cubical Inches, or any other known Meaſure.

WE ſhall meet with no great difficulty in ſolving this Propoſition, if we take Notice of the Demonſtrations of *Chriſtopher Clavius* in *Lib.* V. *Folio* 263. of his *Practical Geometry*, concerning the Cube and the Sphere, where he tells us that the Cube of the Diameter of a given Bullet is to its Solidity as 21 to 11; for Example, let the Diameter of a Bullet be 6 *Unciæ* or Inches of the *Rhynland* Foot, the Cube of 6 is 216; if now by the Rule of Three you ſay, as 21 is to 11 ſo is 216 the Cube of the Diameter to the Solidity; you will have 113, which is the Number of Cubic Inches contained in the given Bullet. Obſerve here, that if you extract the Cube Root of the Number denoting the Solidity of the Bullet, you will have the Side of a Cube that will be equal to the given Bullet in Weight and Solidity.

Furthermore, if by a given Solidity of any Body, you would have the Diameter of a Globe or Ball equal to that Body in Weight and Solidity, you muſt invert the foregoing Analogy, and let it be as 11 to 21; for in that *Ratio* will the Solidity given, be to the Cube of the Diameter of the Ball required. In the above Example you have a Solidity given of 113 Cubic Inches, which if you apply thus to the Rule of Three, and ſay; as 11 is to 21 ſo is 113 the given Solidity to the Cube of the Diameter required, you will have 215, now the Cube Root of this Number *(viz.)* 5 $\frac{2}{10}$ will be the Diameter of a Bullet equal in Weight to the given Solidity.

Again; you may know the Weight of any Bullet by its own Solidity given in Cubic Inches, without the *Calibre Scale* or any Mechanical Invention whatſoever. You muſt firſt know (what I believe is very well known amongſt *Pyrotechnicians*) that the Bullet whoſe Diameter is 4

Unciæ or Inches of the *Rhynland* Foot weighs 8 Pounds of Iron: This being granted, and the Solid Contents of any Bullet being given, you may ſolve it by the Rule of Three after this Manner *(viz.)* as the Cube of the Diameter of 4 *Unciæ* or Inches is to the Weight of 8 Pounds, ſo is the Cube of any other Diameter determined by the ſame kind of Meaſure to its own Weight. Which may be eaſily conceived by the following Example:

64 : 8 : : 216
8

64) 1728 (27 Pounds of Iron.
128

448
448

N. B. 64 is the Cube of 4, and 216 the Cube of 6.

CHAP. VII.

A Method to find by Numbers the Diameter of a Bullet of an unknown Bigneſs by the Diameter of a Bullet of one Pound made of the ſame Metal.

THE Solution of this depends entirely upon the Rules laid down in the firſt *Chapter*, as we ſhall ſhow in the following Example. Suppoſe now, you are asked how many *Unciæ* or Inches of the *Rhynland* Foot conſtitute the Diameter of an Iron Bullet weighing 1000 Pounds. In order to find this, multiply the Cube of the Diameter of a Ball of one Pound, by the Number of Pounds which the Bullet whoſe Diameter you ſeek for weighs, then extract the Cube Root from the Product, and your Queſtion will be anſwered. As here in our Example the Diameter of an Iron Ball of one Pound is 2 *Unciæ* or Inches of the *Rhynland* Foot whoſe Cube is 8; now 1000, the Weight of the given Bullet, being multiplied by 8 it will produce 8000, of which 20 being the Cube Root, that Number is the Diameter of an Iron Bullet weighing 1000 Pounds; that is 20 *Unciæ* or Inches of the *Rhynland* Foot; which was required.

CHAP.

CHAP. VIII.

The Method to examine the Truth or Exactneſs of the Calibre Scale, and of its particular Uſe in Pyrotechnicks.

IT often happens that we dare not rely upon Inſtruments, that have been wrought and adjuſted by the Hands of a Workman, and ſeldom make uſe of them till they have been thoroughly examined by us, as to their Exactneſs and Truth; for from a falſe or miſtaken Conſtruction of them, innumerable Errors and Abſurdities ariſe, as daily Experience evinces. It will be then neceſſary that our *Calibre Scale* ſhould undergo a ſtrict Examination, whether it has been made by your ſelf or an Inſtrument-maker; you may then adjuſt it after this manner. With a Pair of common Compaſſes take the Diameter of a Bullet of one Pound, which muſt be repeated as often as the Length of the Scale will permit, and upon the Points already engraved. Now this firſt Diameter will ſhow all the Points that are diſtinguiſhed or denominated by Cubical Numbers; for Example, being once taken it will extend to 1, which is the firſt Cube; the next time to 8, which is the ſecond Cube; the third time to 27, which is the third Cube; the fourth time to 64, which is the fourth Cube; the fifth time to 125, and ſo on with regard to the reſt. After the ſame manner, the length of the Diameter of 2 Pound will point at the Number 8 twice repeated, *viz.* to 16; and thrice taken, it will point at 27 twice repeated, that is to 54, and ſo on of the other Diameters, as will appear by the Table at the end of this Chapter; in which the Numbers that are under A, are primitive or original, by a Repetition of which are produced all thoſe under B: Thus from the firſt Diameter theſe Numbers ariſe *(viz.)* 8, 27, 64, 125; and all the others that follow in that tranſverſal Order, or in that Line. From the firſt Repetition of the ſecond Diameter will ariſe 16, from the ſecond 54, and ſo on of the reſt. Your *Calibre Scale* having ſtood this Proof, you may ſafely make uſe of it. Now though its Uſes are very various in *Pyrotechnicks*, yet its principal Buſineſs is to Calibre Cannon Bullets, and the Bores or Orifices of warlike Machines, ſuch as are all Pieces of Ordnance, Mortars, Petards, *&c.* As for Example, let there be given a Cannon, whoſe Bore is as in the *Fig.* 8. A, B, C, D, let the Diameter of its Circumference be A, B, which having taken with a Pair of Compaſſes, tranſpoſe it to your Calibre Scale (having firſt allowed for the *Vent* of the Ball, as we ſhall obſerve hereafter) and one of the Feet will point out to ſome Number on your *Scale*, expreſſing the Weight of a Bullet of the ſame Diameter. As in our *Fig.* the Diameter B, E, (without reckoning A, E, which is

the *Vent* of the Ball) being applied to the *Calibre Scale*, prepared for calibring Iron Bullets, you will have the Number 2, which is the Diameter of a Bullet of 2 Pound, by which you will readily conclude, that the given Cannon carries a two Pound Ball. If you apply this ſame Diameter to the other Superficies of the *Scale*, where the Diameters of Lead are marked out, you will find ſome Number denoting the Weight of the ſame Bullet if it was made of Lead.

Obſerve here that if the Diameter of any Bullet being applied to the *Calibre Scale*, does not anſwer exactly to an Integer or Pound; but extends a little beyond it; you muſt know that the ſaid Bullet is heavier than a Pound; now in order to find how much it exceeds it, take notice of the following Method. Let a certain Diameter extend ſomewhat beyond the Point 1 upon your *Calibre Scale*; then ſee how many Parts your Diameter is compoſed of, and likewiſe how many of the ſame Parts conſtitute the Diameter of a Bullet of 1 Pound. Let us ſet the Caſe here, that the Diameter of 1 Pound is divided into 100 equal Parts, and that the given Diameter contains 108 of the like Parts: From thence you will naturally infer, that the Weight of a Bullet of that Diameter, exceeds the Weight of a Bullet of 1 Pound, in the ſame Proportion as the Cube of 108 exceeds that of 100. Now to find out exactly how much the one weighs more than the other, you muſt reaſon after this manner by the Rule of Three: If 1,000,000 the Cube of 100 gives 32 half Ounces (or a Pound) how many will 1,259,712 (which is the Cube of 108) give? This being performed after the common way, it will come out about 40, which will be the Number of half Ounces that your Bullet weighs, and conſequently it will be exactly 4 Ounces heavier than a Bullet of one Pound.

A	B	B	B	B	B	B	B	B	B
1	8	27	64	125	216	343	512	729	1000
2	16	54	128	250	432	686	1024	1458	2000
3	24	81	192	375	648	1029	1536	2187	
4	32	108	256	500	864	1372	2048		
5	40	135	320	625	1080	1715			
6	48	162	384	750	1296				
7	56	189	448	875					
8	64	216	512						
9	72	243							
10	80								

CHAP.

CHAP. IX.

Of the Mutual Ratio *of Metals and Minerals between themſelves, or how to find by the Weight and Magnitude of any Metallic Body the Weight and Magnitude of another. Moreover how to ſet off the Diameters of Bullets made of ſeveral ſorts of Metals and Minerals,* &c. *upon the* Calibre Scale.

SINCE in *Pyrotechnicks* not only Iron Bullets are uſed; but ſuch alſo as are made of different Metals and Minerals, as Lead, Stone and the like; and as in meeting with Bodies made of various Subſtances, it frequently happens either through Neceſſity, or elſe to ſatisfy the Curioſity, that we would gladly know, by means of the given Weight or Magnitude of any Body, the *Ratio* of the Weight or Magnitude of other Bodies made of different Metals, or Materials; I could not omit obliging thoſe who have a Genius or Inclination to *Pyrotechnicks*, by pointing out the Way for them to come at this piece of Knowledge, and that, by ſhewing them in this *Chapter* certain mutual *Ratios* and Properties of Metals and Minerals between one another; which I have here taken from the Works of the moſt learned and experienced Authors. However, I muſt beg of the Reader, that when he meets with theſe mutual Proportions of Metals in other Authors that vary a little from ours; I ſay, I muſt beg of him not to take it amiſs, that we have ſtuck to the lateſt and neweſt Experiments; though we are far from aiming at a Diminution of the Authority of others; eaſily imagining that every one knows well enough (as *Matthias Berneggerus* ſays in his *Annotations upon the Treatiſe of Galileus de Galileis) That pure Metals, that is, ſuch as, free from the Commixture of any other ſort of Metal, do not ſo mutually agree, but that their* Ratios *are ſubject to ſome change, and that they weigh differently when of the ſame Kind. Thus Gold is found to be heavier or lighter than Gold, and Lead than Lead, according as they differ in Magnitude. Moreover, hammered Metal is heavier than that which is caſt, its Parts being more cloſely compacted by being hammered than by being melted. Therefore in vain do you ſeek after this Perfection. The different Specific Gravity of Stones is much more conſiderable than that of Metals. Some of them are very porous, and called Sand Stones; other ſorts of them are more ſolid, but thoſe diſagree greatly from one another in Weight.* Moreover, the different ways of weighing certain grave or heavy Things, have a great Reſemblance to Aſtronomical Obſervations, which almoſt always differ ſome Minutes or Seconds from one another. Now as it is neceſſa-

try that you ſhould know, in what manner the Learned have eſtabliſhed certain Rules, and furniſhed us with infallible Experiments, to determine the different Specific Gravities of all Metals, and to facilitate the greateſt Difficulties you might meet with in your Reſearches after a Certainty upon this Head, I ſhall ſubjoin what *Merſennus* (one of the greateſt Mathematicians our Age has produced) ſays on this Subject in his Book of *Hydraulicks*, Prop. 47.

Firſt then, I made Experiments upon Liquors by pouring them into Phials, which are the beſt the narrower their Necks are, and round the Neck you tye a Thread, or draw a Line that you may exactly fill the Bottle to the ſame height with different Liquors. I need not here mention, that you muſt dry the Bottle well every time, for fear the leaſt drop of the Liquor uſed in a former Experiment by adhering to the Bottle, either within or without, ſhould hinder you from exactly finding out the Specific Gravity of the Liquor you are trying; neither need I mention what has otherwiſe been ſaid of Balances and Steel-yards, and of the Diviſion of Weights in which the greateſt Exactneſs is required.

But this Method is not convenient for weighing hard Bodies, ſuch as are all Metals, except they be firſt melted, and I accordingly took care to melt them; but beſides that all Metals do not fill the ſame Mould (as I ſhewed Prop. 8. Lib. IV. *concerning* Bells) *and that ſome contain more Air than others, and that ſome are not to be melted without a good deal of difficulty, ſuch as Copper and pure Braſs; Stones and Wood cannot be melted at all; I therefore examined Metals after they had been drawn into fine Wire (as may be ſeen from the above-quoted Book of* Harmony) *which not giving me full Satisfaction, becauſe of the various Size of the Wire, the firſt of it that paſſes through the Mould being thicker than what comes through afterwards; and ſince ſome Metals cannot be drawn into Wire no more than Wood or Stones, &c. I thought it neceſſary to think of ſome other way.*

The third Method that I thought might have done was by getting Bodies made into Spheres, Cubes, and Parallelopipeds; but Stones, Metals, Wines, &c. cannot be ſhaped with a Plane or turned in a Leath; and therefore at laſt I find the beſt way to be, to weigh all ſolid Bodies with an exact Balance in Air or Water, or in each ſucceſſively, to find the differences of their Weight. In Air the Liquors are to be examined and compared with Water, weighing them in the above-mentioned Bottle with a narrow Neck: But the reſt of the Bodies being hard might like the Liquors be exactly weighed in Air, if they were equal in Bulk, or if the difference of their Bulk was known; but as their Figures are commonly different and irregular, nothing is more convenient or exact than weighing them in Water; and by comparing a Bulk of Water equal to them, to their Gravity, we may find out how much one Body is heavier than another, and if this be once reduced to a Table the whole Labour will be ſaved.

The ſame Author ſays, *I remember* Dunot *a* Geometrician *was uſed to reduce all Metals to the* Paris *half Pint (or the* Engliſh *Pint) and ſuppoſing that*

that Meaſure of Water to weigh one Pound, he ſaid that the following Metals were in this Proportion; (for Example) ſuch a Meaſure of Iron would weigh 8 *Pound, of Silver* 10 ½ *Pound, of Lead* 11 ½ *Pound, and Gold* 19 *Pound, and that a Leaden Ball whoſe Diameter was* 1 *Inch and* 8 *Lines weighed* 1 *Pound, but when he propoſed to fill a Pint with melted Metals to find the juſt Weight of the reſt, I diſſuaded him from it; becauſe I found that Moulds and Veſſels are not equally filled by different Metals; and that ſome Metals are more full of little Vacuities (or Wind Holes, as the* Smelters *call them) than others.*

It is here then that *Merſennus* ſhews us the mutual Proportions of Metals, which he has very accurately reduced to a Table, aſſuring us that Bodies of Metal of one and the ſame Magnitude, obſerve the following *Ratio* and Order, with reſpect to one another as to Weight; to which we have added the Proportions that Sulphur and Wood bear to the Metals,

Gold	100
Mercury	71 ½
Lead	60 ½
Silver	51 ½
Copper	47 ⅓
Braſs mixed with *Lapis Calaminaris.*	45
Iron	42
Common Tinn	39
Pure Tinn	38 ½
Loadſtone	26
Marble	21
Stone	14
Chryſtal	12 ½
Sulphur	12
Water	5 ⅔
Wine	5 ¼
Wax	5
Oil	4
Lime-Tree Wood	3

The particular and principal Uſe of this Table will be to ſhew, by the known Magnitude and Weight of any Bodies made of any of theſe Materials, the unknown Magnitude and Weights of any other Bodies made of the ſame; and likewiſe their mutual *Ratio's* with regard to Magnitude and Weight. If for Example you would know the mutual *Ratio* of the different Specific Gravities of Iron and Lead; that is, in what degree Lead is naturally heavier than Iron; (ſuppoſing their Bulk to be equal) you muſt look into the above Table, where you will ſee that the Weight of Lead is to the Weight of Iron, as 60 ½ is to 42.

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This being known you will eaſily ſolve this Problem, which is in truth a very excellent one, and perfectly neceſſary in *Pyrotechnicks*. To illuſtrate this, there is an Iron Cannon given whoſe Weight is 2000 Pound; now I demand how many Pounds of Braſs would be requiſite to make another Cannon of the ſame Size, in the ſame Form, and with all the ſame Ornaments and Embelliſhments with the given Cannon. In order to ſolve this, you muſt proceed in this manner, *(viz.)* Having from the above Table taken the Numbers expreſſing the *Ratios* of the two Metals; ſay, as 42 (the number expreſſing the Weight of Iron) is to 45, (the Number expreſſing the Weight of Braſs mixed with *Lapis Calaminaris*) ſo is 2000 Pound, the Weight of the given Iron Cannon, to the Weight of the Braſs one ſought; this being performed, you will find, that the Weight of Braſs mixed with *Lapis Calaminaris*, requiſite to make a Cannon, like the given one, will be 2142 Pound and 27 *Loths*, or 13 ½ Ounces, or thereabouts.

By inverting the Order of theſe *Ratios*, and by knowing the exact Dimenſions of any Body, you will eaſily diſcover the Magnitude of any other Body, whoſe Magnitude is meaſured with the ſame Parts, and is alſo of equal Weight with the given or known Body, and of the ſame Form, though of different Bulk. For Example, let the Magnitude of an Iron Bullet of one Pound be known, whoſe Diameter is divided into 100 equal Parts; (as we have more than once obſerved;) by which you would know the Diameter of a Leaden Bullet of the ſame Weight. In order to do this, look for the *Ratios* of their Specific Gravities in the above Table, for as 60 ½ is to 42, ſo will the Magnitude of an Iron Bullet be to the Magnitude of a Leaden Bullet of the ſame Weight.

Now in order to know the Number of equal Parts which the Diameters of one and the other Bullet ought to contain, I have inſerted another Table which I have carefully calculated, by the help of the Table of Cube Roots in the firſt Chapter of this Book; and likewiſe by the Aſſiſtance of the mutual *Ratios* of the Specific Gravities, as in the above Table; in doing which we obſerved this Method. We multiplied the Root of the hundredth Cube, taken from the Stereometric Table, that is, 464, always by 100, and divided the Product 46400, by the Roots over-againſt the Numbers anſwering to the Specific Gravities of Metals with regard to Gold. For Example, to find the Number of Parts which conſtitute the Diameter of a Leaden Bullet, we divided the Product of our Multiplication abovementined, *(viz.)* 46400, by the 60 ½ Cube Root, (as in our forementioned Table of Roots) which is about 392; now the Quotient 118, is the Diameter of a Bullet of Lead of equal Weight with one made of Gold. By this Method we calculated the following Table, which if you pleaſe to make uſe of, let us to illuſtrate it; ſuppoſe that you want to find the Diameter of a Leaden Bullet of 1 Pound, and that you already have the Diameter of an Iron Bullet of the ſame Weight, divided into equal Parts, which

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we will here (as well as we have elſewhere) ſuppoſe to be 100. This done, range the proportional Numbers of the two Metals in this manner by the Rule of Three *(viz.)* As the proportional Number of Iron (which in the Table is 133) is to the proportional Number of Lead (which in the ſame Table is 118) ſo are the 100 equal Parts, of which the Diameter of the Iron Bullet is compoſed, to the Parts of the Diameter of a Bullet of Lead of the ſame Weight with the Iron one; which was required.

Having worked this Analogy, you will have the Diameter of a Leaden Bullet conſiſting of $88\frac{25}{133}$ Parts of the ſame Bigneſs or Nature as the 100 Parts, into which the Diameter of an Iron Bullet is divided. Thus you are to proceed to find out the Diameters of Bullets, of the other Metals, but of equal Weight with one of Iron. In ſhort, the Diameter of a Bullet made of any kind of Metal being known, you will have the Diameters of all the reſt, by taking their reſpective Numbers from our Table of Proportions, and then working them by the Rule of Three. By what we have been ſaying, we ſhall readily come at all the Diameters that are uſually found upon the *Calibre Scale.* Moreover we may not only have the Diameters of Globes or Bullets, but alſo all the Homologous Sides of any Bodies, as well regular as irregular (provided they are made of ſuch Materials as are to be found in our Table) together with their mutual *Ratios* as to Magnitude, as may be conceived by the following Table. As for Example, let there be given a Cube of Wood, whoſe Weight is 10 Pound, and let it be required of you to make a Cube of Copper of the ſame Weight with the given one; to do this, divide one Side of the given Cube into a certain number of equal Parts; (but it may not be improper to tell you, that the more Parts you divide it into, the more exact will your Work be;) let us here ſuppoſe the Side of the given Cube to be divided into 60 equal Parts; then take their proportional Numbers from the following Table, and range them as uſual in caſes of the Rule of Three *(viz.)* as 309, the proportional Number of Wood, is to 128, the proportional Number of Copper, ſo is 60, the Number of Parts into which the Cube of Wood is divided, to the number of the ſame Parts requiſite for the Side of a Cube of Copper, of the ſame Weight with the Cube of Wood which was given; from which there will ariſe this Number $24\frac{164}{309}$, which are the Number of Parts of the ſame Bigneſs, or Nature with thoſe into which the Cube of Wood was divided, as are neceſſary for the Side of a Copper Cube, of the ſame Weight with the Wooden one.

What has now been done with regard to the Side of a Cube, as a regular Body, may be done with reſpect to the Homologous Sides of an irregular Body; and thus may you have the Magnitudes of *æquiponderant* Bodies, made of different Metals, ſuch as Braſs, Iron, *&c.* and all by the help of Models or Moulds, (to uſe the term in the *Proplaſtic* Art) ſuch as the Moulds of all the Pyrotechnical Bodies, which are for

the moſt part irregular, as all Cannons, Mortars, Petards, and ſuch like Machines; whether they be made of Wood, Wax, Lead, or any other Metal or Mineral whatſoever. To conclude, we may eaſily come at a Knowledge of the Encreaſe or Augmentation of any Body, by ſuch means as we have been ſpeaking of, and by the aſſiſtance of the Table of Cube Roots given in the firſt Chapter; always obſerving that the given and required Body be exactly of the ſame Form. Concerning this Subject you may, if you pleaſe, have recourſe to the 25th Problem in *Galileo*'s Treatiſe of the *Sector*; wherein he teaches how to find out the ſame thing by an Inſtrument of his own Invention.

Obſerve here that we have not given the Proportion of mixed Metals to the others; it being very difficult to aſcertain any Rules concerning it; becauſe the Founders, and ſuch like Workmen, have very various Methods of allaying, or mixing Metal when they caſt Cannon, of which we ſhall ſpeak more fully in another Place. We have, however, obſerved by Experience, that the Weight of a Metal mixed in ſuch Proportion, as that in 100 Pound of Copper, there is 20 Pound of Braſs mixed with *Lapis Calaminaris* (which the *Latins* called *Aurichalcum*, the *Germans Meſſing*, the *Poles Moſiads*, and we *Lattin*) and 10 Pound of Tinn; (an Allay which is eſteemed the ſtrongeſt, and is now in general uſe amongſt the *European* Nations) comes the neareſt in Weight to the Specific Gravity of Braſs made with *Lapis Calaminaris*.

Diameters of Æquiponderant *Bullets, divided into equal Parts.*

Gold	100
Mercury	111
Lead	118
Silver	122
Braſs or Copper	128
Braſs with *Lapis Calaminaris*	130
Iron	133
Common Tinn	136
Pure Tinn	137
Loadſtone	156
Marble	168
Stone	192
Chryſtal	201
Sulphur	202
Water	266
Wine	267
Wax	271
Oil	276
Lime-Tree Wood	309

APPENDIX.

WE may eaſily ſolve both the one and the other Queſtion, given in the above Examples, by another Method; as ſuppoſe we wanted to know the Diameters of Bullets or Balls, by the known Diameter of any given Ball, or that we would have the Homologous Sides of any Body, whether regular or irregular, by the known ſides of any given Body: (ſtill obſerving that they be of equal Weight.) In order to come at this, proceed as follows. With any Scale whatſoever, take the proportional Parts of Metals as you find them in the above Table, and ſet them off upon the Line A, B, *Fig.* 10. beginning from A towards B, making a Point or Diviſion where every Diameter terminates, and write under each Diviſion a Name or Character, to denote the Metal to which it belongs: Thus will your *Figure* be adjuſted. I ſhall now illuſtrate the Uſe of it, by an Example of the ſame nature with that which I gave laſt. Let there be given, for Example, the Side of a Silver Cube, by which you are to find out the Side of a Chryſtal one of the ſame Weight. With a pair of Compaſſes take the right Line in your *Figure*, which is equal to the Side of a Cube of Silver; then fixing one Foot at the Point diſtinguiſhed by the Word *Silver*, deſcribe an Arch of a Circle with the other, towards which from A, produce the Tangent A, C, *ad infinitum.* Then taking the Diſtance between the Point diſtinguiſhed by the Word *Chryſtal*, and the Tangent A, C, you will have the Side of a Chryſtal Cube of equal Weight with the given one that was of Silver, and conſequently all the Diſtances between the Points upon the Line A, B, and the Tangent A, C, will be the Sides of Cubes, made of Metals differing from a Silver Cube in Kind, but equal to it in Weight.

CHAP. X.

Of Weights; *their Difference, and Co-equation, or Equality to one another.*

THE *Weights* which were uſed by the *Ancients*, were very different from ours both in Name and Effect; and were by them changed and altered a thouſand ways, as well in conſideration of the various Nations they traded with, as the ſeveral Commodities that they weighed. It is the ſame thing in our Days; for the *Weights* uſed by the *French*, differ from thoſe uſed by the *Spaniards*, which are again different from thoſe of the *Italians*, *Germans*, *Poles* and *Engliſh*; this variety as to *Weights* holds good through all the Nations in the World; where they bear particular Names in the Languages of their reſpective Countries.

Moreover there are ſome *Weights* that are uſed for weighing Gold, Pearl, Coral, and other Things of Value only; and others for Iron, Copper, Lattin, Lead, Tinn, Sulphur, Allum, Wax, Tallow, Hemp, Wool, freſh or ſalt Meat, Butter, Cheeſe, and the like Goods of Bulk. Furthermore, there are particular *Weights* uſed by *Phyſicians*, *Apothecaries* and *Surgeons*, with which they weigh and adjuſt the Medicines which they prepare for the humane Body. It is in this Chapter then that I propoſe to entertain you with the Difference of all theſe *Weights*; beginning firſt with thoſe of the *Ancients*, then proceeding to ours, and finiſhing with thoſe of the moſt Modern Date, all which we ſhall enumerate and reduce to an Equality between themſelves; which done, we ſhall ſhow of what Uſe their Co-equations or Equalities are in *Pyrotechnics*.

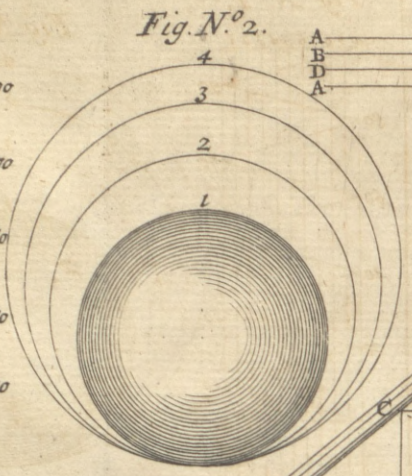
As to the *Weights* of the *Ancients*, and the particular Difference between them, the Writings of both *Greek* and *Latin* Authors will fully inform us: We have here collected ſome of them, of which we ſhall ſpeak as we go along. In the firſt place the *Ancients* generally divided their *Weights* into two Claſſes, *(viz.)* the *Greater* and the *Smaller*; of the *Greater* there was

The TALENT, which amongſt the *Hebrews* was a kind of *Weight* (without any Mark upon it,) of 3000 *Shekels*, as may plainly be ſeen in the xxxviiith Chapter of *Exodus*, wherein is mentioned a Sum of 100 *Talents*, and of 1775 *Shekels*, which was collected after 603,550 Men had paid each half a *Shekel*. Now the *Hebrew Talent* contained 100 *Hebrew Minæ*, and 120 of *Attica*, or 1500 *Ounces*, 12000 *Drams*, or 125 Pounds, each Pound weighing 12 *Ounces*. With the *Talent* they weighed Gold, Silver and Copper: See *Villalpandus* upon this Subject in his third Volume, where he powerfully refutes thoſe who differ from him in Opinion. But Authors diſagree as to the *Weight* of the *Shekel*. *Merſennus*, in his Treatiſe of *Meaſures*, *Weights* and *Coins*, aſſures us, he found that a *Shekel* of Silver (which he would have to be equal in Weight with one of Gold) weighed 268 *Grains*, and from thence concludes, that the *Hebrew Talent* of 3000 *Shekels* was equal to 87 Pounds (of 16 *Ounces* each) 3 *Ounces*, 6 *Drams*, and 2 *Denar*, or to 804,000 *Grains*. From whence we ſee that the *Talent*, as calculated by *Villalpandus*, exceeds that of *Merſennus*, by 6 Pounds (of 16 *Ounces* each) 8 *Ounces*, 2 *Drams*, and 2 *Denar*. Some are of Opinion, that the *Hebrews* had two ſorts of the *Shekel*, *(viz.)* the common one, or the Prophane *Di-drachma*, and the *Tetra-drachma* of the Sanctuary, which was double the common one. But you may if you pleaſe read *Villalpandus* upon this head, where he diſputes with great Energy againſt *Grepſius*, and maintains that the *Shekel* was but of one kind, which was of equal Value with the *Athenian Stater*, and not of two, diſtinguiſhed by the Denominations of *Prophane* and *Sacred*. The *Drachm* which was the fourth part of a *Shekel*, as mentioned in St. *Luke*, Chap. xv. verſe 8. was

equal

Fig N.° 1.

Fig. N.° 2.



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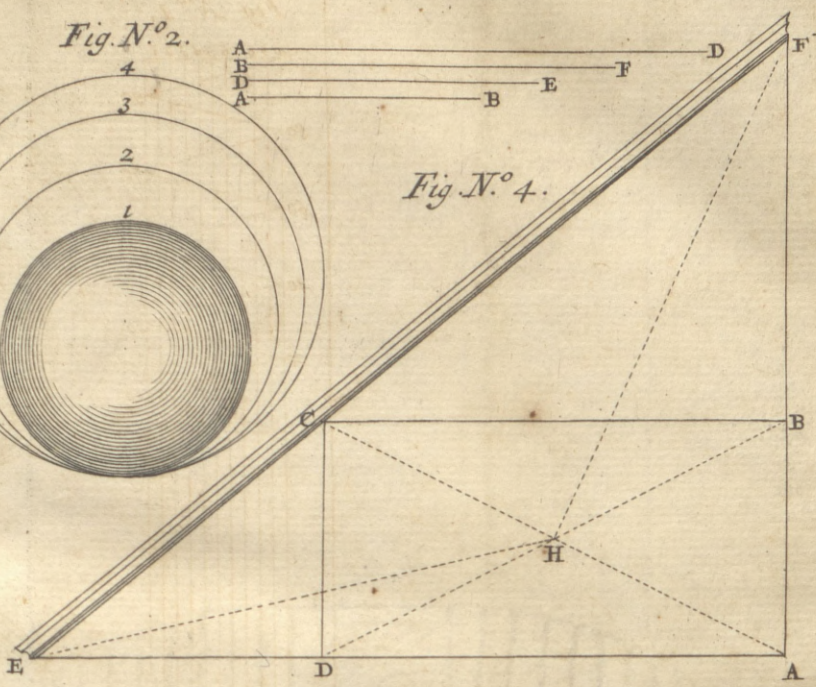
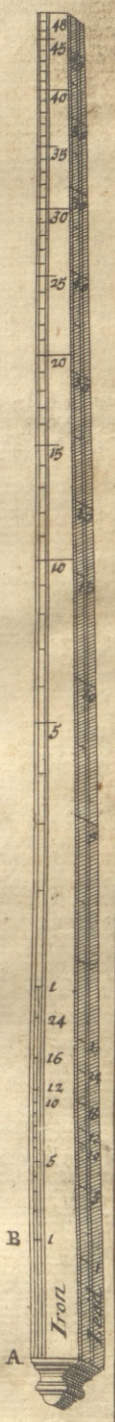


Fig. N.° 3.



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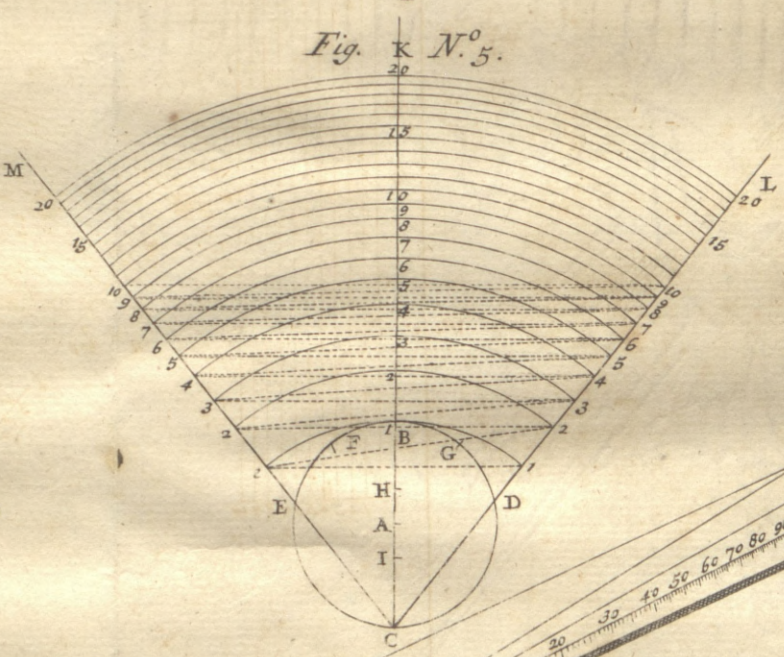

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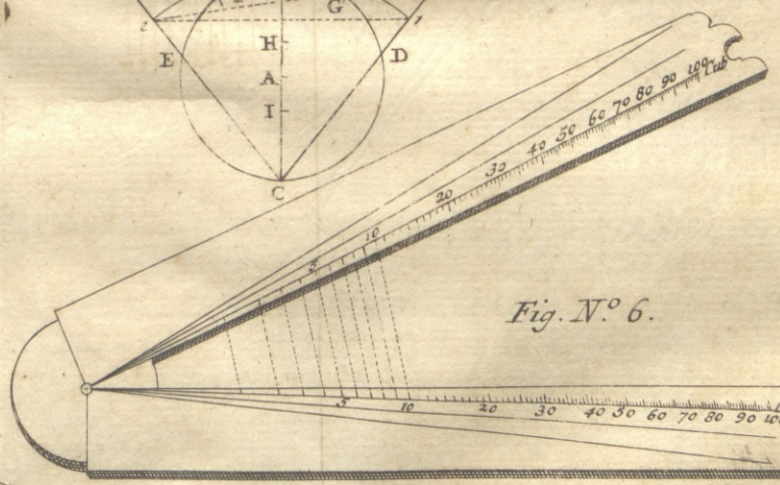

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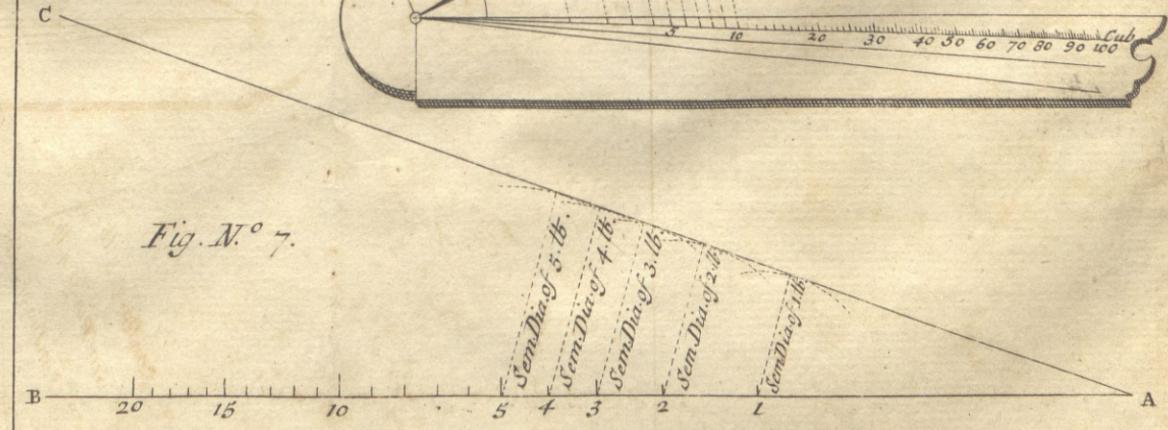

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equal to a *Roman Denarius*; of which in St. *Matth.* Chap. xviii. ver. 22. or as the half, in St. *Matthew*, Chap. xvii. ver. 27. The *Shekel* was compoſed of 20 *Oboli*, which the *Hebrews* called *Gerah*, and the *Chaldeans*, *Maha*; the *Obolus* according to the common Opinion of the *Rabbins* weiged 16 *Grains* of Barley; from whence (as they equal the *Grains* of an *Ounce*, which we ſhall ſpeak of hereafter) we may make a *Shekel* or 20 *Oboli* to contain 320 *Grains*. Thus 3000 *Shekels* will weigh 960,000 *Grains*, or 104 Pounds (of 16 *Ounces* each) 2 *Ounces*, 6 *Drams*, and one *Denarius*. But if you would know any thing farther, relating to the Weight of the *Hebrew Shekel*, read *Merſennus of Meaſures, Weights and Coins*, together with the Authors he quotes upon that Subject.

By Authors we find it for a certainty that the *Talent* amongſt the *Romans* was of three ſorts. The *Leaſt* of the three weighed 84 Pounds *Roman*. The *Mean* one was 120 Pounds, as *Vitruvius* ſays in the laſt Chapter of Book X; where he relates, that *Heliopolis* was ſo firmly walled with Flints, and ſo ſtrongly fortified with Hides, that it could bear the Shock of a Stone of 360 Pounds Weight, thrown from the *Baliſta*; now this was the Weight of three *Talents*, each of which was 120 Pounds. You will find the *Third* and *Greateſt Talent*, in *Suidas* and *Heſychius*, who both aſſert it to have been 125 Pounds, which is a *Weight* equal to an *Hebrew Talent*.

The *Grecian* or *Attic Talent* was 6000 *Drams*, or 60 *Attic Minæ*, as *Suidas* relates from *Feſtus*. According to *Villalpandus* it was equal to half of the *Hebrew Talent*; but according to *Suidas* and *Heſychius*, the half of the *Roman Talent*; that is 62½ Pounds *Roman* Weight. The Value of the *Attic Talent* in Money was 600 Crowns; which may give us an Idea of the famous and memorable Liberality of *Alexander* the *Great* towards Men of Learning, when he preſented his Maſter *Ariſtotle* with 800 *Talents*, as a Gratification for the Trouble he had been at, in deſcribing to him the Nature of all Animals; which amounted (as ſome will have it) to 480,000 Crowns: And likewiſe when he ſent Ambaſſadors to the Philoſopher *Xenocrates*, with a Preſent of 50 *Talents*, which anſwered to 30,000 Crowns. Beſides the *Talents* I have already mentioned there were ſeveral others; as

The *Thracian Talent*, which weighed 120 Pounds. The *Ægyptian*, which was 80 Pounds. The *Alexandrian*, which was half of the *Attic Talent (viz.)* 31 Pounds, 3 *Ounces*. The *Syrian*, of 1500 *Drams*, or 15 Pounds, 7 *Ounces*, and 4 *Drams*; and that of *Ægina*, which weighed no more than 10 *Drams*.

As to the *Leſſer Weights* of the *Ancients*, you will find amongſt the *Hebrews*

The MINA or MANEGH, which was 30 *Shekels* or 120 *Drams*.

The *Grecian Mina* or *Mna* (μνα) was of two ſorts *(viz.)* the *Leſſer* of 75 *Drams*,

And the *Greater* (which was bigger than the new one of *Solon)* 100 *Drams.* The *Dram* was divided into 6 *Oboli*; the *Obolus* into 2 *Semi-oboli*; the *Semi-obolus* into 3 *Chalci*; the *Chalcus* into 5 *Leptes.* But for weighing of *Drugs* and *Medicines*, the Phyſicians and Surgeons divided the *Mina* into 16 *Ounces*; the *Ounce* into 8 *Drams*; the *Dram* into 3 *Scruples*; the *Scruple* into 2 *Oboli*; the *Obolus* into 2 *Semi-oboli*; the *Semi-obolus* into 1 ½ *Siliqua*, and the *Siliqua* into 4 *Grains* or *Moments.*

The *Mina* of *Alexandria* was 20 *Ounces*; and in ſhort to conclude with the *Mina*, the *Ptolemaic* was 8 *Ounces* only.

The POUND was what the *Romans* properly called a *Weight*, or *As*, or *Aſſis*; this *Weight* was the *Leaſt* of the *Greater* Sort or Claſs, and the *Biggeſt* of the *Leſſer.* It was commonly 12 *Ounces*, and this *Roman Pound* was 4 *Drams* lighter than the *Attic Mina.* The *Pound* was originally divided into 12 *Ounces* only; then the *Sextans* was 2 *Ounces*; the *Quadrans* 3 *Ounces*; the *Triens* 4 *Ounces*; the *Quincunx* 5 *Ounces*; the *Semis* 6 *Ounces* (which was alſo called *half a Pound;)* the *Septunx* was 7 *Ounces*; the *Beſſis* 8; the *Dodrans* 9; the *Dextans* 10; and the *Deunx* 11 *Ounces.* The *Pound* was again divided into other ſmaller Weights; as, 24 *half Ounces*; 36 *Duellæ*; 48 *Sicilica*; 72 *Sextulæ*; into 84 *Denarii*, 168 *Victoriati*, and 288 *Scriptula.*

Beſides all this, the *Pound* was a kind of *Meaſure* amongſt the *Romans*, which was divided into 12 Parts, which they called *Unciæ* or *Inches*; this they called the *Menſural* or *Meaſuring Pound*, to diſtinguiſh it from the *Ponderal* or *Weighing Pound.* Now this *Menſural Pound*, (according to *Galen* in his Vth Book *of the Compoſition of Medicaments)* was a kind of Veſſel made of Horn, with which the *Romans* uſed to meaſure Oil; and was divided by certain Lines drawn either withinſide or without into 12 Parts, which were called *Unciæ.* *Galen* farther informs us in the VIth Book of the ſame Treatiſe, that the whole *Menſural Pound* was equal to but 10 *Ounces* of the *Ponderal Pound*, and conſequently was 2 *Ounces* lighter.

We have now ſpoken ſufficiently of the *ancient Weights*; let us proceed to examine the various *Weights* in preſent Uſe: amongſt which, whether they be of the *Greater* or *Leſſer* ſort, we ſhall find a wide difference. But as we have no Terms to expreſs them by in our Language, no more than we had for thoſe of the *Ancients* which are equally foreign to us; we ſhall call them by the Names they bear in the Countries where they are uſed, and particularly by ſuch Terms as are the moſt common among Merchants: And this we ſhall do with all poſſible Brevity.

DOLIUM (which alſo is the Name of a Veſſel anſwering to a *Tunn)* is a *Weight* much uſed in *Poland* (where it is commonly called *Beczka)* and is 50 *Stones*, or 1600 Pounds: I ſuppoſe them here to be *Stones* of *Warſaw*, which weigh 32 Pounds each.

The MIGLIER, which we call the *Millier*, is a *Venetian Weight* of 40 *Miriads* (called in that Country *Miri)* each weighing 25 Pounds; thus

thus the whole *Millier* will weigh 1000 Pounds, allowing 12 *Ounces* to each *Pound.*

The BACCAR in the Kingdom of *Calicut*, is a certain *Weight*, that at *Lisbon* anſwers to 5 great *Quintals*, and weighs in all 640 Pounds.

CALLA, is an *Alexandrian Weight* of 960 Pounds.

CARGO, or CARICO, *Cargoe*, or *Lading*, is a *Weight* commonly uſed in *France*, *Spain*, *Italy*, and *Portugal*; this is properly the *Load*, or *Burthen* of an Horſe, Aſs, or Mule. In *Spain* it is 3 *Quintals*, which are 360 Pounds, and ſometimes 432 Pounds; at *Venice* and *Antwerp* it is 400 Pounds. At *Lions* and every other Place in *France* it is 270 Pounds, and ſometimes 300 Pounds. The *Schiffpfundt* of the *Germans* has ſome Affinity to this ſort of *Weight*, as we ſhall ſhow in its proper Place.

BIRKOWIEC, a *Weight* among the *Muſcovites*, and the Inhabitants of *White Ruſſia*, contains 10 other ſmaller *Weights*, (which the People of thoſe Countries call *Pud*) each of which weighs 36 Pounds, from whence it is that this *Weight* is 360 Pounds in all.

The SCIBA of the *Egyptians* weighs 320 Pounds.

The RIVOLA or *Romula*, a Weight uſed in the Country about *Damaſcus*, is 225 Pounds.

STAR, amongſt the *Venetians*, weighs 360 Pounds, and ſometimes 220, 180, 130, or 120, and ſometimes but 110 Pounds. This Difference ariſes from the ſeveral ſorts of Goods they weigh with it; which I ſhall not here dwell upon.

The WAGE, a Weight amongſt the *Belgians*, weighs at *Antwerp* 165 Pounds; at *Bruges* in *Flanders* 30 *Stones*, or 180 Pounds; ſometimes at the ſame Place it is but 20 *Stones* or 120 Pounds; with this they weigh Butter and Cheeſe.

QUINTAL, QUINTALO and QUINTALIS; a *Weight* amongſt the *Spaniards* and *Portugueze*. In the City of *Leon* it weighs 100 Pounds. At *Seville* the great *Quintal* is 144 Pounds, and contains 4 *Robes*, or *Arrobas* of 42 Pounds each: the little *Quintal* is only 28 Pounds. There alſo they have another ſort of *Quintal* which is 120 Pounds, or 4 *Robes* of 30 Pounds each. The *Portugueze Quintal* is 128 Pounds, and contains in like manner 4 *Robes*, of 32 Pounds each. This is their *Greateſt Quintal*: the *Leſſer* is but 112 Pounds; which alſo contains 4 *Robes*, weighing only 28 Pounds each. In the ſame Country the *Quintal* of Wax weighs 1 ½ of the *Leſſer Quintal*, and is therefore 168 Pounds. In the Kingdom of *Fez*, the *Quintal* is 66 Pounds of *Antwerp*, and in *Morocco* and *Guinea* 129 Pounds.

CANTAR and CENTNER is what was anciently called the CENTENARIUS or *Hundred*, which weighed 100 Pounds: from whence it was that in *Nonius* the Soldiers cried out: *Quid fit? Baliſtas jactas Centenarias*; if it be only that thoſe powerful Machines threw out Stones of 100 Pounds? But now this *Weight* is varied prodigiouſly, and ſuited to the Convenience of a vaſt many Nations that make uſe of it. In

France

France (for Example) in the City of *Paris*, it is divided into 4 *Quartrons*, or *Quarters*, of 25 Pounds each. At *Lions*, *Thoulouſe*, *Avignon*, and *Montpellier* it weighs 112 Pounds. In *Spain* it is 4 *Robas*, each *Roba* 30 Pounds, which added together make 120 Pounds, and anſwer to the Weight of a *Quintal*. In *Puglia*, *Calabria*, and *Candia*, as alſo at *Conſtantinople*, *Alexandria*, *Aleppo*, and the Iſlands of *Cyprus* and *Rhodes*, it is 100 *Rotules*; in *Sicily* 61 *Rotules* of 30 Ounces each, make a *Hundred* or *Centenary*. At *Damaſcus* it contains 5 *Zurls*, or 5 *Stones*, of 20 *Rotules* each. In *Barbary*, it is 5 *Robes*, and every *Robe* 20 *Rotules*; at *Oran* it is 4 *Robes*. In *England* it is 112 Pounds. At *Noremberg* and moſt of the chief Towns in *Upper Germany* it is 100 Pounds, 120 Pounds, and ſometimes 132 Pounds. In *Sileſia* and *Vratiſlaw* it weighs 5 *Stones* of 24 Pounds each, which is 120 Pounds; the ſame it weighs at *Hamburgh* and *Dantzick*. At *Koningsbergh* it is 138 Pounds. At *Lubeck* and *Stetin* in *Pomerania* it is 121 Pounds. At *Cracow* in *Poland* it is 138 Pounds. At *Warſaw* it weighs 5 *Stones* of 32 Pounds each (as I have already ſaid) which make 160 Pounds; in purſuance to the *Orders* eſtabliſhed in that Kingdom in the Year 1565. At *Leopole* in *Ruſſia*, it is 5 *Stones* of 30 Pounds each.

The ROBE or *Arroba*, is a *Spaniſh* and *Italian Weight* of 36, 32, 30, and 28 Pounds, as I have already ſaid.

The STONE, commonly called *Stein* in the *Upper* and *Lower Germany*, is much uſed by the *Germans*, *Flemmings*, *Hollanders*, and all the other Nations that inhabit the Borders of the *German Ocean*, and the *Baltick Sea*; as in *Poland*, *Lithuania*, &c. It is likewiſe uſed in *Italy*, *(viz.)* at *Rome*, *Florence*, *Bologna*; as well as *Hamburgh*, *Lubeck*, and *Stetin*; in all which Places it weighs 10 Pounds: At all theſe Places they have likewiſe one of another ſort, which is double of the firſt, and conſequently weighs 20 Pounds. At *Vratiſlaw* in *Sileſia*, it is 24 Pounds; at *Cracow* 25 Pounds; at *Warſaw* and *Lublin* 32 Pounds, in purſuance to the Orders iſſued out by *Sigiſmundus Auguſtus* in the Year 1565; at *Leopole* it is 30 Pounds; at *Dantzick* the *Stone* is of two kinds, the *biggeſt* of which is 34 Pounds, with which they weigh Flax and Wax; and the *leaſt* is only 24 Pounds, with which they weigh Drugs, Spices, and all Aromatick things. At *Koningsbergh* it is alſo of two ſorts, the *biggeſt* weighing 40 Pounds, and the *leaſt* 25 Pounds. At *Elbing*, *Vilna* in *Lithuania*, at *Riga*, and at *Revel* in *Livonia*, it is 40 Pounds; and at *Thorn* 24 Pounds only.

NAGEL is a *Weight* in *England*, which is particularly uſed for weighing Wool: at *Bruges* in *Flanders* it is 6 Pounds. Furthermore 45 *Nagels* conſtitute a certain *Weight* which they call *Wage*, 2 *Wages* make a *Sack*, and 3 *Sacks* make a *Seltier* or *Serpelier*. But in *England* the *Nagel* weighs 7 Pounds; 3 *Hundreds* and $\frac{1}{4}$ make a *Sack* of Wool, which is 52 *Nagels*; the TOD is likewiſe an *Engliſh Weight*, and is 4 *Nagels*.

The

The ROTULA or SCUTARIA is a *Weight* in *Italy*, and in ſeveral Parts of the *Eaſt*, as in *Arabia*, *Syria*, *Greece*, *Rhodes*, and *Cyprus*: It is divided into 12 *Ounces*, *Sacros*, or *Sachoſes*; into 24 *Sexatios* or *Siclos*; into 48 *Denarii*, 7 of which make an *Ounce*; into 96 *Darquins*, or *Drams*; into 288 *Scruples*; into 576 *Orloſſats*, or *Oboli*; into 864 *Danigs*; 1728 *Kirats*, or *Carats*, or *Siliqua*, and into 6912 *Keſtufs*, which ſignify *Grains*. According to *Nicholas Tartaglia*, in his Twelfth Queſtion, the *Rotule* or *Rotula* at *Venice*, weighs 2 Pound, or 33 *Ounces* and $\frac{1}{3}$, and 3 *Rotules* make 100 Ounces. In *Sicily* the *Rotule* is 30 *Ounces*; at *Alcairo* it is 6 Pounds; at *Aleppo* 60 *Ounces*; at the ſame Place the *Ounce* is divided into 8 *Metallicks* or *Metecalles* (this is the *Turkiſh* term for *Drams*) and one *Rotule* is 480 *Metallicks*, each of which weigh 1 $\frac{1}{2}$ *Peſo*, and 10 *Peſo* make an *Ongue*, or *Ongy*; in fine, 50 *Metallicks* make a *Turkiſh Mark*; but 32 of them would conſtitute ours.

The MINA, MANEG, or MNA, in *Egypt*, weighs 16 *Ounces*; in *Syria* and *Judea* 18 *Ounces*; but in ſome other Places it is found that the *Ancient Grecian Mina* weighed 100 *Drams*.

The POUND, which in *Germany* is called the *Pfundt*, in the *Low-Countries*, *Pond*, and by the *Poles*, *Funt*; is in great requeſt all over *Europe*, and well known to moſt Nations of the World. But as it is very variouſly divided by different Nations, and is obſerved to be very much altered as to Weight, and the Number of ſmaller Weights it is divided and ſubdivided into, I ſhall enlarge a little more than ordinary upon this Subject, and inſert here its Differences and unequal Diviſions, as practiſed in the ſeveral Provinces and Cities of *Europe*. For this once I ſhall follow the Order of *Marius Merſennus*, who was a very nice Man in his Obſervations. I have taken Part of what follows from a Treatiſe of his, of *Meaſures*, *Weights and Coins*. He begins then with the *French Pound*, with which he compares, and to which he reduces the Weight of the Pound in ſeveral other Countries. Firſt he divides the *French Pound* into 16 *Ounces*, the *Ounce* into 8 *Drams*, the *Dram* into 3 *Scruples*, or *Deniers*; ſo that the whole *Pound* contains 384 *Scruples* or *Deniers* in all; the *Scruple* is divided into 24 *Grains*, by means of which Diviſion the *Ounce* will contain 576 *Grains*, and conſequently the whole *Pound* is 9216 *Grains*. As to the *Grain*, though it is a very ſmall and inconſiderable Part of the *Pound*, yet he ſays the Goldſmiths in *France* uſually ſubdivide it into 512 *Particles*. He then aſſures, that he tried and found $\frac{1}{176}$ of a *Grain* weighed at leaſt as much as 40 Particles or Grains of Sand, from whence it follows, that a Particle of Sand weighs $\frac{1}{40480}$ of the *Grain* of an *Ounce*.

Having thus aſcertained the *French Pound*; he teaches a Method by which *Coiners* may make their Grains as nice as poſſible, *viz. They muſt firſt divide the* Pound *into* 16 *equal Parts*, *or* Ounces; *then ſubdivide each ſixteenth Part*, *or* Ounce, *again into* 24 *equal Parts*, *which will be* Deniers, *and then each* Denier *into* 24 *other equal Parts*, *which will be*

Grains. *This laſt Diviſion may eaſily be done with a little Plate of Copper or Silver, very thin and longiſh, that it may be conveniently divided into* 24 *Particles or little Plates; but Care muſt be taken that the Plate is equal and uniform throughout all its Dimenſions. Some* (ſays he) *think it may be done with more Exactneſs with Braſs or Iron Wyre, as being more even and regular than Plates of Copper or Silver; but (to ſay my Thoughts concerning this Method) if they ſeek after an extream Quality, by Pieces of Wyre, they take a wrong Method to find it; and the reaſon is, becauſe the firſt End of the Wyre that paſſed through the Hole or Mould, widened it in ſome Degree or other, and thus that which came through after it will be bigger, and conſequently heavier than the firſt. This Inequality has been ſufficiently examined, by the Gold Weights, and diſcovered by the moſt exact Scales, and it is impoſſible to remedy it, whether you file the Wyre or cut off any Part of it, ſo that you will never this way find out that perfect* Geometrical Equality *which you ſought after.*

Having done with the *French*, he proceeds to the *Roman Pound*, which differs very little in its Diviſion from the firſt. For it is divided into 12 *Ounces*, the *Ounce* into 8 *Drams*, then into 24 *Deniers*, or into 612 *Grains*. Now the different Weight of the *French* and *Roman Pound*, appears from the Experiments he himſelf made; for he ſays that the Difference between the *Roman* and *French Ounce*, is 40 *French Grains*, and that the *Roman Dram* is 67 *French Grains*, and conſequently that the *French Dram* is 5 *Grains* heavier than the *Roman*; and that the *Roman Pound* is equal to 11 *Ounces*, 1 *Dram*, and 1 *Denier*: Now if you reduce this into *Grains*, you will find that the *Grains* of the *Roman Pound* will be equal to 6432 *Grains* of the *French Pound*, and conſequently that the *French Pound* will be to the *Roman Pound* as 9216, is to 6432.

In the third Place he gives us the *Engliſh Pound*, which is what the Goldſmiths particularly make uſe of to weigh Gold and Silver, and which they commonly call *Troy Weight*. This *Pound* is divided into 12 *Ounces*, each of which is heavier than the *French Ounce*, by 10 *French Grains*. Thus the Proportion of the *French* to the *Engliſh Pound* is as 9216 to 7032. The Merchants of this Iſland have another ſort of *Pound*, which they divide into 16 *Ounces*, and which they call *Avoirdupois*; the *Ounce* of this *Pound* is 40 *French Grains* lighter than the *French Ounce*, and conſequently equal to a *Roman Ounce*: Thus this whole *Pound* is equivalent to 14 *Ounces*, 7 *Drams*, and 18 *Grains* of *French* Weight. From this we infer that the *French Pound* is to the *Engliſh Pound* of *Avoirdupois Weight* as 9216 is to 8586. Now as it happens that the Ounce of *Troy Weight*, which being 10 *Grains* heavier than the *French* contains 840 *Grains*; it is plain that the *Engliſh Grains* are $\frac{1}{7}$ and half lighter than the *French Grains*. And thus as theſe *Grains* are of the ſame Weight in one and the other *Engliſh Ounce*, conſequent-

ly the *Pound Avoirdupois* of 16 *Ounces*, will be equal to 14 *Ounces* and an half *Troy Weight*.

From *England* he goes on to the *Low Countries* or *Holland*, where he aſſures us he had often made the Experiment, and found, that the *Low Country* Half *Ounce*, weighs half a *French Grain* more than the *French* one. Thus the *Dutch Pound* of 16 *Ounces* will weigh 9232 *French Grains*, and conſequently the Proportion between the *French* and the *Dutch Pound* will be as 9216 is to 9232. In the *Low Countries* they divide the *Ounce* into 20 *Anglics*, (which the *Dutch* call *Engelſchen)* and the *Anglic* is ſubdivided into 32 *Grains*. Thus the *Dutch Ounce* will weigh 640 *Dutch Grains*, and from thence it will follow that the *Dutch Grains* are about $\frac{1}{16}$ lighter than the *French ones*.

As to the *Spaniſh Pound*, he does not pretend to know any thing of that by his own Experience; and only ſays, that he has heard that it is equal to 15 *Ounces*, and 24 *Grains* of *French Weight*. But I find by *Villalpandus*, that the *Pound* is of three Sorts among the *Spaniards (viz.)* the *Bigger* of 32 *Ounces*; the *Mean* of 16; and the *Leſſer* (which they call *Argentaria)* of 8 *Ounces*.

I ſhall here ſubjoin the Diviſions and Subdiviſions of the *Pound*, in ſeveral other particular Provinces and Cities, from my own Experience, or from the Information I have had from others.

In *Poland* the *Royal Pound* is 32 *Loths* or *Half Ounces*; each *Loth* weighing 1 $\frac{1}{2}$ *Sicilica*, which in the Language of the Country are called *Skoyciec*; therefore the whole *Pound* weighs 48 *Sicilica*. The *Dantzic Pound* is in like manner divided into 32 *Loths*, and the *Loth* into 4 *Quarters*, which they alſo call *Quintleyn*; the *Quarter* into 4 *Seſteres* or *Ponderal Nommules*. Conſequently the *Dantzic Pound* is compoſed of 512 *Nommules*. Now ſince it happens that 32 of theſe *Nommules* make an *Ounce* of a *Pound*, it will neceſſarily follow, that 4 *Nommules* will make a *Dram*, and thus a *Nommule* will weigh 18 *Grains*; from whence it will follow, that the whole *Pound* will be compoſed of 9216 *Grains*, which are equal in Number to the *Grains* that conſtitute the *French Pound*, as we have before obſerved from *Merſennus*. Now in order to know what Proportion a *Grain* of the *Dantzic Pound*, may bear to the *Grain* of a *French Pound*; pleaſe to take notice of what follows. *Peter Crugerus*, one of the moſt famous Mathematicians in *Dantzic*, aſſures us (in a little Treatiſe of *Arithmetic* which he wrote in *Germany*;) he had often experienced that the half *Pound* of *Cracow* (which the *Poles* call *Grzywna*, and the *Germans Marck)* weighed 16 *Loths*, and 12 *Nommules* of *Dantzic*; that is, that the half *Pound* of *Cracow* is 12 *Nommules* heavier than the half *Pound* of *Dantzic* of 16 *Loths*. From whence we may conclude, that the *Dantzic Pound* is to that of *Cracow*, as 9216 is to 9648. But inaſmuch as it is the moſt current Opinion, amongſt Goldſmiths, as well as the moſt received one amongſt the generality of the *Poles*, that the *Cracovian* half *Pound* ought to weigh 7

Impe-

Imperial Dollars, or *Silver Crowns*, and inaſmuch as the aforementioned *Peter Crugerus* ſays he himſelf tryed and found that 7 *Dutch Dollars* weighed 16 *Loths*, and 12 or 13 *Dantzic Nommules*, and that upon a ſecond Tryal, he found that 7 new *Saxon Dollars* weighed 17 *Loths* and one or two *Nommules* of *Dantzic*; it will follow that 7 *Dollars* want but little of being equal to the *Cracovian* half *Pound*; which agrees very well with the common Opinion with regard to this matter; which on the other hand agrees with the Obſervations of *Crugerus*, who having taken upon him to examine the Weight of the *Cracovian* and *Dantzic* half *Pound*, we ſhall particularly ſtick to what he ſays; that we may avoid the Confuſion and Trouble, which a Diverſity of Obſervations might introduce into our Diſcourſe.

But ſince *Merſennus* in his Treatiſe of *Meaſures*, &c. makes the *Imperial Dollar* and that of *Burgundy* or *Flanders* (which the *French* call *Patagons*; and which are very well known all over the *Low Countries*) to weigh 22 *Deniers*, or 528 *French Grains*, it will follow, that the *Cracovian Pound*, weighing 14 of the like *Dollars*, will be equal to 7392 *French Grains*; and the *Pound* of *Dantzic* to 7061 of the like *Grains*. The *Warſovian Pound* is an *Ounce* lighter than the *Dantzic Pound*, as I myſelf have experimented, it weighing but 8640 *Dantzic Grains*; therefore the *Warſovian* bears ſuch Proportion to the *Cracovian Pound*, as 8640 does to 9648; that is, it is lighter by 1008 *Grains*, which are equal to one *Ounce*, 5 *Drams*, 2 *Deniers*, and 21 *Grains*. But it weighs 6619 $\frac{47}{67}$ *French Grains*. The *Pound* of *Koningsberg* bears ſuch Proportion to that of *Dantzic* as 8121 $\frac{3}{7}$ does to 9216, as appears by *Peter Crugerus*, who found that 160 *Pounds* of *Koningsberg*, were equal to 141 *Pounds* of *Dantzic*. The *Pound* of *Vilna* is equal to 29 and $\frac{1}{11}$ *Loths* of *Dantzic*, and weighs 8378 $\frac{2}{11}$ of *Dantzic Grains*. The *Pound* of *Noremberg* is equal to 11511 *Dantzic Grains*; therefore it exceeds the *Dantzic Pound* by 2295 *Dantzic Grains*; which are equal to 7 *Loths*, 3 *Drams*, 2 *Deniers* and 5 *Grains*. That of *Cologne* weighs 39 *Loths* and 3 *Nommules*, or 11286 *Dantzic Grains*; therefore it exceeds the *Dantzic Pound* by 2070 *Grains*, or 7 *Loths*, 2 *Deniers*, and 6 *Grains* of *Dantzic Weight*. In purſuance of an *Imperial Mandate*, the half *Pound* of *Cologne* ought to weigh 8 *Imperial Dollars*, which *Crugerus* ſays he found to be the Weight of it; the whole *Pound* therefore muſt weigh 16 *Dollars*, and conſequently it will bear ſuch Proportion to the *Cracovian Pound*, as 8 does to 7; or that it muſt be $\frac{1}{8}$ or 2 *Ounces* heavier than that of *Cracow*. *Crugerus* moreover obſerved that the *Dutch* half *Pound* (which is called *Troy-gewicht*, and *Troyſche Marck* by the *Germans*) weighs 20 *Loths* and 10 *Nommules*, or 5940 *Dantzic Grains*; therefore the whole *Dutch Pound* is equal to 11880 of the ſame *Grains*, and exceeds the *Dantzic Pound* by 2664 *Grains*, or 9 *Loths* and one *Dram*; whereas it exceeds the *Cracovian* but by 2232 *Dantzic Grains*, or 7 *Loths*, 2 *Drams*, and 3 *Nommules*. From whence we may conclude, that

that the *Ounce* of this *Dutch Troy Pound*, as commonly divided into 20 *Anglics*, or into 640 *Grains* (which ſome mean by the Word *Aſen*) contains 742 ½ of *Dantzic Grains*, and conſequently that the *Dantzic Grains* are lighter than thoſe of *Holland*. The ſame *Dutch Ounce*, (according to *Willebrordus Snellius*, in his *Eratoſthenes Botanic.* Lib. II. Cap. V.) weighs 9 Golden *Roſe-Crowns*, commonly called *Roſen-Nobel* or *Roſe-Nobles*, which *Crugerus* having tried, found that 4 of thoſe *Nobles* or *Crowns*, weighed 2 *Loths*, 9 *Nommules* and ¼ of *Dantzic*, or 742 ½ *Grains*. The ſame Author in the ſame place will have it, that this *Ounce* is equal to the *old Roman Ounce*. Again, if we compare this *Batavian Pound* with that of *France*, we ſhall find that it weighs near 9104 *French Grains*. From whence it is evident, that the above Obſervations of *Merſennus*, concerning the *Dutch* or *Batavian Pound*, differ from this laſt; inaſmuch as *Merſennus* has made the *Dutch Pound* to weigh 9232 *French Grains*, whilſt *Crugerus* allows it to be equal to no more than 9104 of the ſame *Grains*; ſo that there is a Difference of 128 *Grains* between them. The *Pound* of *Elbing* is exactly equal to that of *Dantzic*. But let us now proceed to the Diviſions and Subdiviſions of the *Pound*, as they are variouſly practiſed in ſeveral other Provinces and Cities. As for Example; at *Rome*, *Florence*, and *Bologna*, they have a certain *Pound* of 30 *Ounces*, with which they commonly weigh Wax and Wool. At *Milan*, *Pavia*, and *Cremona*, the *Pound* with which they weigh Fleſh, is 28 *Ounces*. At *Venice* the *Pound* is divided into 12 *Ounces*, 72 *Sextules*, 1720 *Silics*, and 6912 *Grains*. At *Vienna* in *Auſtria*, the *Pound* is divided into 32 *Loths*, 128 *Quints*, 512 *Deniers*, and 12800 *Grains*. At *Antwerp* the *Pound* is of 16 *Ounces*. At *Bruges* in *Flanders* of 14 *Ounces*; but at the ſame Place they have another ſort of *Pound*, which is divided into 16 *Ounces*; therefore the 100 Pounds of 16 *Ounces* each, are equal to 108 Pounds of 14 *Ounces* each: At the ſame Place they ſubdivide the *Ounce* into 2 *Loths*, the *Loth* into 4 *Siſanits*, the *Siſanit* into 2 *Drams* or *Quints*. In the Kingdom of *Fez*, the *Pound* is of 18 *Ounces*.

In ſhort the *Medicinal Pound*, which is properly the *Old Roman Pound*, is divided into 12 *Ounces*, into 24 *half Ounces*, into 69 *Drams*, into 288 *Scruples*, into 576 *Oboli*, into 1728 *Silica*, and into 5760 *Grains*.

I ſhall here ſubjoin the Characters uſed by *Phyſicians*, *Apothecaries* and *Surgeons*, to expreſs all the *Parts* of a *Pound*: for Example; the *Pound* is expreſſed thus ℔, an *Ounce* ℥ j; two *Ounces* ℥ ij, and ſo on till you come to half a *Pound*, which is thus expreſſed ℔ſs; a *Dram* ʒ j; two *Drams* ʒ ij; and ſo on to Eight. The *Scruple* thus ℈; and the *Grain* thus gr: Pleaſe to obſerve that we ſhall make uſe of theſe Characters for the future, to avoid the too frequent Repetition of the Words.

There are 9 Veſſels of Metal, made like Cups, that anſwer to the Weight of one *Pound*. The firſt with all the reſt in it weighs one *Pound*, or 16 *Ounces*, and by itſelf 8 *Ounces*. The Second with thoſe contained

in it weighs 8 *Ounces* or half a *Pound*, and by it ſelf 4 *Ounces*. The third with thoſe contained in it 4 *Ounces*, and by itſelf 2 *Ounces*. The Fourth with *&c.* 2 *Ounces*, and by itſelf 1 *Ounce*. The Fifth *&c.* 1 *Ounce*, and by itſelf 4 *Drams*. The Sixth *&c.* 4 *Drams*, and by itſelf 2 *Drams*. The Seventh *&c.* 2 *Drams*, and by itſelf 1 *Dram*. The Eighth *&c.* 1 *Dram*, and by itſelf 1 ½ *Scruple*. And the laſt 1 ½ *Scruple* or 36 *Grains*.

Obſerve here that we have ſaid, in the former Part of this Chapter, that the *Hebrew Shekel*, according to *Merſennus*, weighed 268 *French Grains*; but ſince *Merſennus*, in Lib. IX. of his *Treatiſe* of *Meaſures, Weights and Coins*, will abſolutely have it, that the *Imperial Dollar* anſwers nearly to 2 *Shekels*, inaſmuch as 2 *Shekels* are equal to 536 *French Grains*; it muſt follow that 28 *Shekels* are equal to 14 *Imperial Dollars*, each *Dollar* weighing 536 *French Grains*; which being compared with the *Cracovian Pound*, it will infallibly be found to weigh 7504 *French Grains*. Again, the *Low-Country Pound* (whoſe Proportion to the *Cracovian Pound* we have already conſidered) will be found to weigh 9104 of the ſame *Grains*; which Number, as it does not differ very much from the Obſervations of *Merſennus*, as to the Proportion that this *Pound* bears to that of *France*, ſeems to me to be the moſt reaſonable, and therefore I chooſe to ſtick by this Proportion; for I am of Opinion, that *Merſennus* has aſſigned a Weight to the *Imperial Dollar* which would have agreed better with the *Flemmiſh Patagon*; this latter being in ſome degree different from the former, whether as to Purity of Silver, Value and Weight, it being commonly lighter. But I ſhall leave this to the Deciſion of thoſe who are perfectly skilled in what relates to Money and Coins.

The MARK of Money, which the *Latins* called *Marcha* and *Libra*, *Nummularia*, or *Nummaria*, and which we ſhall call with them the *Nummular Mark* or *Pound*, is much uſed by Monneyers, Goldſmiths, and all thoſe who are concerned in the Manufacture of Gold and Silver. In *Poland*, that of *Cracow* is 8 *Ounces*, or 16 *Loths*, which are equal to 17 *Loths*, 7 *Nommules*, and ¼ of *Dantzic*. That of *Dantzic* weighs alſo 16 *Loths*, or 256 *Nommules*, or 1024 *Quarters*. The proportion of this to the above-mentioned half *Pound* of *Dantzic* is as 4054 is to 4608; that is, that the latter exceeds the former by 554 *Grains*, which are exactly 1 *Loth*, 14 *Nommules*, and 14 *Grains*. The *Dantzic Mark* is particularly uſed in weighing Silver, and is divided into 24 *Sicilics*, each of which is ſubdivided into 4 *Quarters*; but that with which they weigh Gold, Pearl, and all ſorts of Jewels, is divided into 24 *Carats*, each of which weighs 12 *Grains*, or 4 *Quarters*. The *Mark* of *Elbing*, is the ſame with that of *Dantzic*. That of *Antwerp* weighs 8 *Ounces*, or 160 *Anglics*, or 5120 *Grains*; there likewiſe the *Anglic* is ſubdivived into 6 *Carats*; thus 960 *Carats* conſtitute a *Mark* of *Antwerp*; 200 of which *Marks* are Æquiponderant with 105 common

Pounds

Pounds of the ſame Place. The *Dutch Mark* is 8 *Ounces*, the *Ounce* 24 *Nommules*, and the *Nommule* 24 *Grains*. The *Roman Mark* is 8 *Ounces*, the *Ounce* 8 *Drams*, the *Dram* 3 *Scruples*, the *Scruple* 2 *Oboli*, the *Obolus* 3 *Silics*, and the *Silic* 4 *Grains*. The *French Mark*, according to *Merſennus*, is 8 *Ounces*; but we have already ſaid enough of its Subdiviſions. The *Venetian Mark* is likewiſe divided into 8 *Ounces*, into 32 *Quarters*, into 1152 *Carats*, or *Silics*, and into 4608 *Grains*. The *Nummular* or *Money Pound* of *Florence* is divided into 24 half *Ounces*, or *Loths*, into 288 *Nommules*, and into 6912 *Grains*. The *Golden Mark* of *Genoa* is 8 *Ounees*, or 192 *Nommules*, or 4608 *Grains*. At the ſame place the *Silver Pound* is divided into 12 *Ounces*, 288 *Nommules*, and 6912 *Grains*. The *Money Pound* of *Naples* is 12 *Ounces*, or 96 *Octaves*. In *Portugal* it is 8 *Ounces*, or 64 *Octaves*, or 288 *Grains*. In *Miſnia* and *Saxony* it is 8 *Ounces*, or 193 *Nommules*, or 4608 *Grains*. And to conclude, that of *Nuremburg* is 16 *Loths*, or 64 *Quarters*, or 256 *Primes* or *Nommules*, or 1024 *Sixteenths*.

We have I think ſaid enough of the different Properties and Proportions of *Weights*, as well *Ancient* as *Modern*; and I believe that no body will, after reading this, meet with any Difficulty or Doubt, concerning their Co-equations and *Ratios* to one another. I would only obſerve to you, that if you are deſirous of being farther ſatisfied upon this Head, you may have recourſe to a ſmall *Flemmiſh Book*, publiſh'd by an Anonymous Author at *Amſterdam*, in the Year 1647, entitled *Treſoor van de Gewichten, Maten van Korn ende Landen*, &c. from whence I borrowed a great many curious things, which are inſerted in this Chapter. After having reduced almoſt all the *Weights* in the Univerſe, and compared them with the *Ancient Roman Standard*, and to one another; I have with the utmoſt Care calculated a *Table* in a circular Form, the Uſe of which I ſhall illuſtrate by the following Propoſition.

Let there be given (for Example) a piece of Ordnance made in *Italy*, that carries a Ball or Bullet of 60 ℔ *Roman*; to know how many *Pounds* of *Amſterdam* it would weigh; you may proceed in the following manner (*viz.*) as 100 ℔ *Roman*, are to 76 ℔ of *Amſterdam*, in the given *Table*, ſo is 60 ℔ *Roman*, which is the Weight of the given Bullet, to the Weight of it in *Amſterdam Pounds*, which was required. This being performed after the common way, you will have 45 $\frac{1}{2}$ ℔, which will the Weight ſought of the given Bullet. This will hold good in all the like Caſes, and it will be impoſſible for you to err, if you follow the Rules we have laid down.

I ſhall here, by way of *Corollary*, ſubjoin ſome Remarks taken from *Merſennus*'s Book of *Meaſures* &c. to prevent our being no more perplexed by the Defect, and great and frequent Imperfection of *Weights*, than by the great Difference and Variety between them; but that on the

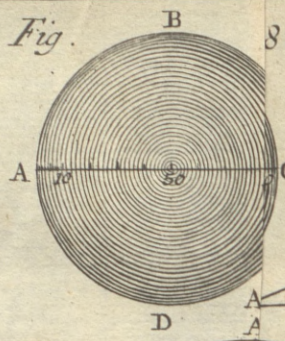
the contrary, when we meet with any thing of this kind that cannot poſſibly be rectified by our utmoſt Induſtry and Application, it may be given over and rejected, in conſideration of that great Degree of Incertitude, that inſeparably accompanies almoſt every human Action.

Having carefully ſought after the Cauſe of all theſe Differences and Defects, which could no ways be attributed to the Balance, nor to the various Tenour of the Air, no more than to the breathing of thoſe who lifted up or held the Balance, which may ſeem to have a troubleſome Effect, and to diſturb the Æquilibrium; *I at length found out, that all this Diverſity proceeded from the* Standard Weights, *which are kept in Town* Halls *and* Mints, *for the Examination of all other* Weights; *inaſmuch as theſe three* Models *or* Standard Weights, *of which the biggeſt is* 64 Marks, *the mean* 32, *and the leaſt* 16, *or* 32, 16, *and* 8 *Pound, do not ſo exactly correſpond with each other, but that there is a Difference between them of ſeveveral* Grains; *by which means the* Ounce *of one is not exactly the* Ounce *of the other. But that we may not raſhly accuſe the* Wardens, *who have the keeping of theſe* Weights, *nor the* Workman *who made them, of either Negligence or Diſhoneſty: I muſt here ſay, that it is a very hard Matter, or that in ſhort it is impoſſible that theſe* Weights, *let them have been made in what Manner, or of what Material ſoever, nay if their Conſiſtence had been as durable as Adamant, to preſerve their original Size in its utmoſt Extent, or that nice Proportion with which they were at firſt endued.*

Let there be (for Example) two Braſs Weights *of one Pound each, adjuſted to each other with all the Nicety that the Induſtry of Man is capable of, yet this nice Equality cannot always, (nor indeed for any conſiderable time,) remain in that extream Degree of Perfection as you may imagine; and the reaſon of it is, becauſe, as theſe* Weights *are from time to time handled, in the daily Examination of other* Weights, *they wear out or waſte a little by that Means, ſo that the more they are handled or moved about, the lighter they will become: from whence it happened that the famous Examiner of* Weights, Semillardus, *diſcovered his* Mark, *or half* Pound, *to have loſt* 3 Grains *of its Weight in* 2 *Years time; which conſequently would have diminiſhed it* 300 Grains *in* 200 *Years, and in ſhort an entire* Ounce *or* 576 Grains *in the Space of* 432 *Years.*

But you may ſay, in anſwer to this; that theſe two Standard Weights *ſhould be equally handled, as often as there is occaſion to make uſe of them, to the end that the one may be leſſened in an exact Proportion with the other; but to this I reply (not to mention the Difficulty of managing ſo, as that both ſhall be agitated with an equal Motion, and handled ſo nicely alike, that a Perſon might ſay he had equally leſſened them) who is he that can boaſt of knowing perfectly how much his firſt handling wore them, how much it wore them in a Year, or indeed in an Age? Let us therefore conclude, that we can be ſure of nothing upon this Head, no more than in ſeveral other Caſes wherewith we in vain perplex ourſelves. Let us be well ſatisfied, if there ſhould be a* Grain *or two of Difference between two*

Fig. 8.



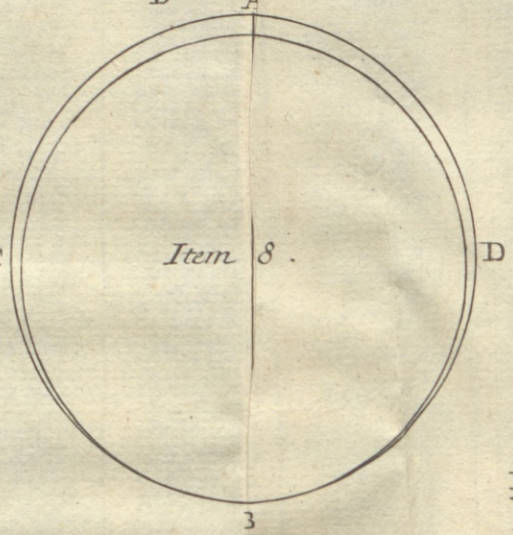


Fig. 10.

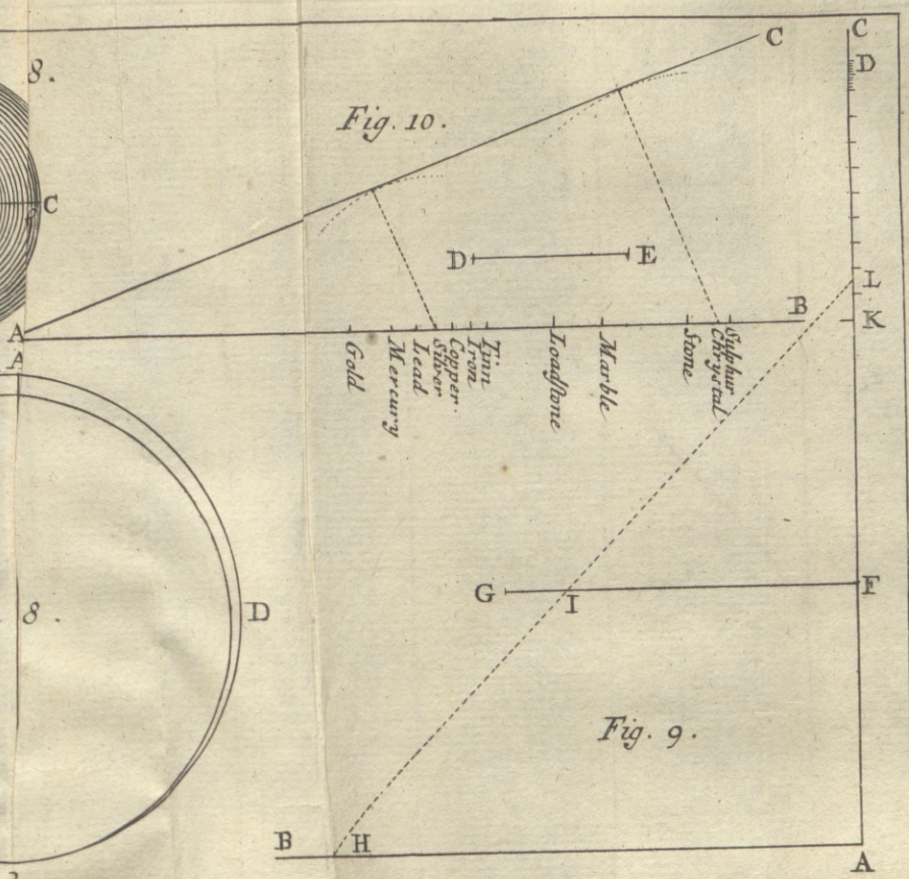
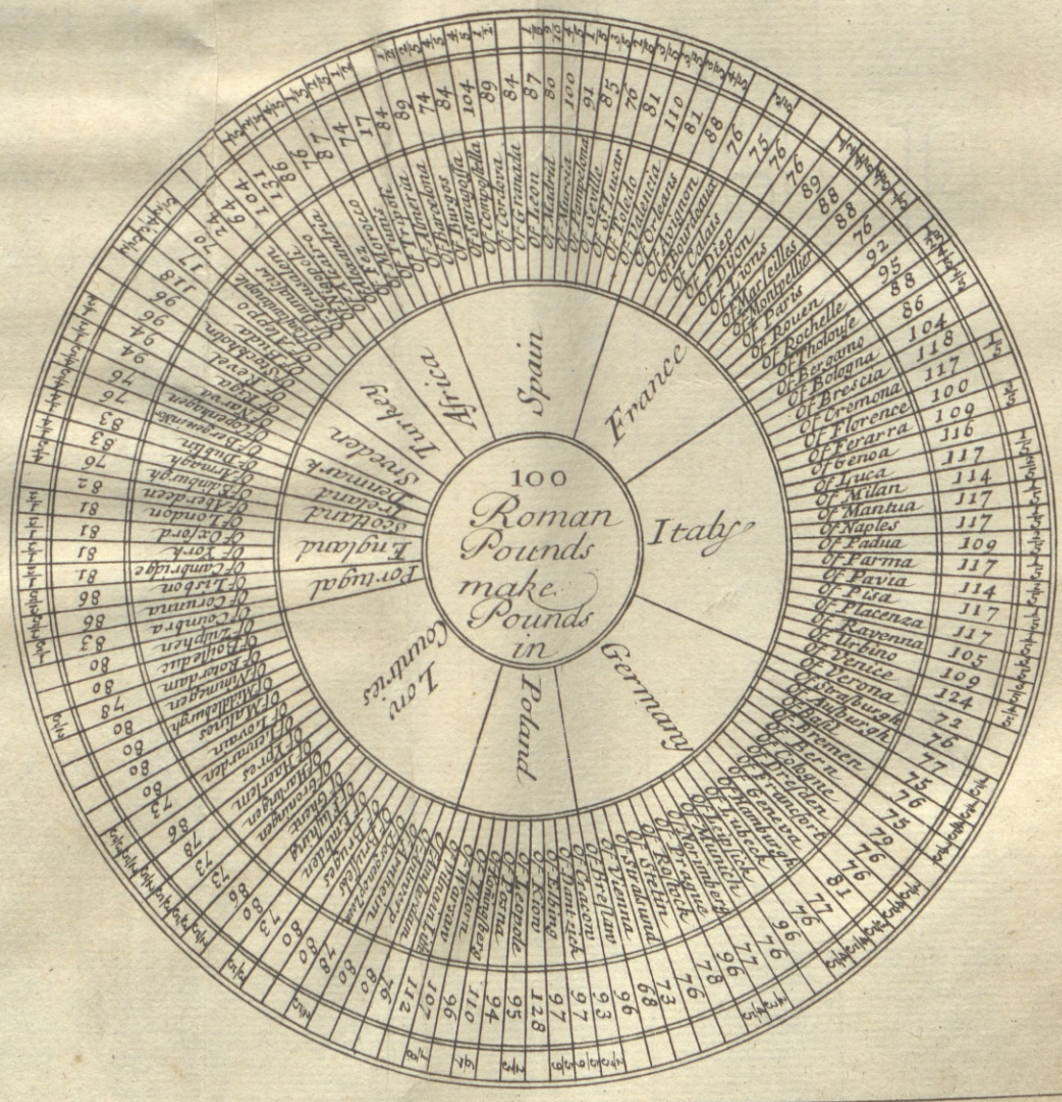


Fig. 9.



B

Weights; *which is ſuch a Trifle, that it cannot well be ſaid to be injurious either to the People or the State; for to what purpoſe ſhould we ſeek after that Geometrical Perfection, which is not only incompatible with all Human and Mechanical Things; but alſo, abſolutely inconſiſtent with the Weakneſs of our Nature?*

CHAP. XI.

Of Weighing INSTRUMENTS.

WE uſually examine all manner of *Weights*, with two ſorts of *Inſtruments*, *viz.* the *Balance*, or *Scales*, and the *Steel-yard*, which ſome call the *Statera Romana*. We ſhall here ſet forth in the moſt conciſe Manner we are able, the Origin of both the one and the other of them; their Properties, their Uſe, their particular Forms and Figures, and in ſhort the manner of their Conſtruction.

Of the BALANCE.

Some will have it that the *Balance*, and *Steel-yard* derive their Origin and fundamental Principles, from theſe two general *Axioms* in *Mechanicks (viz.)* that *Equal Weights weigh equally at equal Diſtances, but unequally, at unequal Diſtances:* and this other, *that unequal Weights weigh unequally at equal Diſtances, but that they weigh equally at unequal Diſtances, provided that their Diſtances are in a reciprocal Proportion to their Weights.* Thoſe who would be ſatisfied as to theſe Demonſtrations, may find them in *Guido Ubaldus, Galileus, Simon Stevin, John Buteo*, in *Guevara*, and ſeveral other Mechanical Writers, who have enlarged very much upon this Subject. As for me, though I know that this Matter has been very learnedly treated of by a great many, I yet think they have left me ſome little to ſay; or at leaſt I may have leave to entertain ſuch as are Lovers of the Mathematicks, with an Abridgement of what ſo many others have diſcourſed of ſo largely, and demonſtrated with ſo much Prolixity. I ſhall then endeavour to render my Eſſay uſeful by means of one Figure, which I ſhall here give you.

Suppoſe, for Example, that the Right Line A, B. in *Fig.* 11, be the *Brachia* or Beam of the Balance, and that G is the Axis or Center. Now let us ſuppoſe that A and B are *æquidiſtant* from G, and the Weights ſuſpended at thoſe two Points will infallibly *æquiponderate*, if they are equal to one another; it being very evident from our general *Poſtulata*, that two Bodies of the ſame Weight, and at equal Diſtances from their common Center, are in *Æquilibrio*, in the Point of their common Conjunction, and in the Termination of their equal Diſtances. Thus the

Bodies E and F, being ſuppoſed of equal Weight, and the Right Line A and B, by the Extremities of which they are ſuſpended, being divided in ſuch a Manner, that A, G, and B, G, are equal, and A and B *æquidiſtant* from the Center, it will neceſſarily follow that the Point of *Æquilibrium* of both Bodies is in G, which it would not be if they did not weigh equally, or if they had been ſuſpended at unequal Diſtances; neither of which happens in the preſent Caſe. But you muſt obſerve here, that the *Weights* muſt hang by Lines that are perfectly perpendicular. For ſuppoſe the Body E be ſuſpended at the Point K, and that the Right Line G, K, be equal to the Right Line A, G, or G, B, and that the Line of Direction K, I, by which the Body E, tends towards the Center of the Earth, interſects the Right Line A, B, in I; now becauſe G, I, is not equal to A, G, or G, B, the Body E will no longer *æquiponderate* with F ſuſpended at B; by which it muſt plainly apear, that for Bodies to be in *Æquilibrio*, it is not only neceſſary that they be of equal Weight, but likewiſe that they be *æquidiſtant* from the Center of the *Balance*. I ſhall now ſhow you the *Figure* of it, and furniſh you with ſome uſeful Obſervations concerning the nice Conſtruction and Examination of it.

In *Fig.* 12. you have the Form of the Beam or *Brachia* of the *Balance*; whereby Smiths, Scale-makers, *&c.* may ſee how to adjuſt them. The right Line A, B, is the fundamental Line of the whole *Machine*, which is exactly divided in the middle by the Right Line C, D, in the Point E; to this are joined two others that are parallel to it, and *æquidiſtant* from E *(viz.)* F, G, and H, I, divided in the like manner by C, D, in K, and L; from L deſcribe with the Line L, M, the Circle M, N, W, P, divide the inferior Semi-diameter of this Circle into 4 equal Parts, at the Points L, O, and R, and from thence you may eaſily know the Diſtances of the Parallels G, F, and H, I, from the Line A, B, *(viz.)* the eighth Part of the Diameter M, W, or the fourth Part of the Semi-diameter L, M. From the Point K, the Center of the *Balance*, deſcribe a Circle with the prickt Line K, a, or E, K, which is included in the Square, b, c, d, e, and where Workmen commonly put a kind of Nail or *Axis* which is round at Top, a little angular at the Bottom, and pointed at the End, upon which the whole *Machine* turns; now the Diameter of this *Axis* ought to be very little leſs than the Semi-diameter of the Circle included within the Square. This *Axis* is fixed in an Handle, (the *Figure* of which you may ſee under the Letter B,) which ſuſtains the whole Burthen of the Balance and Weights. The *Brachia* A, E, and *E*, *B*, are meaſured from E, and terminate always in the Lines M, W, or P, N, ſix, eight or more times meaſured from E towards A or B. Obſerve here, that the longer the *Brachia* are, the nicer will the *Balance* be. They make the *Fulcrum* of the Beam after this manner, *(viz.)* Deſcribe a Circle from L with the prickt Line L, D, or L, C, (which is equal to $\frac{3}{4}$ of the Semi-diameter L, M,) then divide the

Peri-

Periphery of it into 6 equal Parts in the Points C, S, h, D, g, V, then through the Points g, V, and h, S, produce the right Lines g, T, and h, Q, till they join the right Line T, Q, drawn parallel to the right Line A, B, through the Point C: Now if from T, and Q, you deſcribe the Segments V, f, and Z, S, the upper part of the Beam will be formed. Then from P, and N, ſet the Diſtance between P, U, and N, S, towards X and Y; and from I and H, draw the right Lines Y, I, and H, X, towards Y and X, and you will have the thickneſs of the *Brachia*. Moreover from the Points X, D, and D, Y, between X, D, and D, Y, let there be the equilateral Triangles, X, D, i, and D, Y, k. In ſhort, having deſcribed the two Segments X, D, and D, Y, from the Points k and i, you will have the lower part of the Beam formed. The *Trutina*, or *Cock* C, M, muſt be as long as one of the *Brachia*. The Heads or Buttons of the *Brachia* A, B, are made by certain ſmall Circles deſcribed round A and B, with the prickt Line of a quarter of the Semi-diameter M, O; the ſmall *Axes* at the Heads of the *Brachia*, or Points of Suſpenſion from which the Scales commonly hang, are made in the ſame Form as the great *Axis* in the Center of the *Balance*. We may eaſily determine their Proportion by making ſmall Squares under A and B, between the parallel Lines A, B, and H, I, the Interſection of whoſe Diagonals will give their Centers, from whence ſmall Circles may be deſcribed in their juſt Proportion to the *Axis* of the *Balance*, in the Form of which they muſt be wrought.

The *Scales* muſt be of equal Weight; and if the Ropes or Chains (by one of which great *Scales* are always ſuſpended) are of the Length of the whole Beam they will be the more exact. This is what I had to ſay with regard to the Conſtruction of the *Balance*, which is ſufficient for this time. I ſhall now ſubjoin ſome Obſervations which I have taken from good Authors, which may be of uſe to you in judging of the Perfection or Imperfection of any *Balance* whatſoever.

OBSERVATION I.

The longer the *Balance* is the more exact will it be, inaſmuch as it's *Brachia* deſcribe a larger Circle than the *Brachia* of ſmall ones; from whence alſo in large *Balances* their Velocity is encreaſed, they being leſs attracted by the Center to a circular Motion, which is unnatural to them; and, on the contrary, leſs hindered from a rectilinear or perpendicular Motion, which is natural to them, and by which the Extremities of the *Brachia* would deſcend, if not confined and carried round by the Center of the *Balance*; therefore the longer the *Brachia* are, the more free and unconſtrained will their Motion be; thus the greater the Circumferences they deſcribe, the nearer will their Motion approach to a right Line: If to this you object, that great *Scales* are not near ſo nice and exact as the ſmaller which are uſed by Lapidaries and Goldſmiths; that

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is entirely owing to the coarſe and ſtubborn Materials, of which large *Balances* are commonly made, whereas the ſmaller are curiouſly wrought and poliſhed. To conclude; the *Ratio* of their Velocities is as the Diameters of the Circumferences or Circles they deſcribe; and the longer the *Brachia* of a *Balance* are, by ſo much will they be more ſenſibly acted upon, by the *Weights* ſuſpended from them, and will deſcend with the greater Velocity.

OBSERVATION II.

Scales when without *Weights* may be in *Æquilibrio*, though at the ſame time they may be ſubject to *Deceit*. For if the *Axis* or Center of Motion is not exactly in the middle of the *Beam*, and the *Scale* that hangs by the ſhorteſt *Brachium* is made of knotty Wood, or has had melted Lead poured any where into it, the *Balance* may be in perfect *Æquilibrio*. Let the ſhorteſt *Brachium*, for Example, be divided into 10 Parts, and the longeſt into 15, and let the *Scale* ſuſpended by the *Latter* weigh 10, and that ſuſpended by the *Former* weigh 15; and their *Weights* and *Diſtances* being by this Means in a reciprocal Proportion, they will be in *Æquilibrio*; and ſo they will continue to be if you put in the *Scale* of the ſhorteſt *Brachium* a Weight of 6 *Ounces*, (for Example) and in the other a Weight that is to 6 as 10 is to 15; upon this Account it was, that *Ariſtotle* (in his Book of *Mech. Queſt.* I.) rebuked ſo ſharply thoſe Dealers in Purple; for 4 being to 6 as 10 is to 15; they certainly ſold 4 *Ounces* of Silk for 6, which was very unjuſt. But you will eaſily diſcover the *Deceit* by reciprocally ſhifting the *Weights* from one *Scale* to the other.

OBSERVATION III.

It is not ſufficient to allow for the Length of either of the *Brachia* by adding a greater or leſſer *Weight* to either Side; for it is better not to admit or truſt to this Method of making amends for the different Lengths of the *Brachia*, though it might in ſome ſort be allowed: But be aſſured that the nearer the *Brachia* are to an Equality between themſelves, the more certain and uſeful the *Balance* will be: And if ever you are obliged to make uſe of ſuch that are not ſo very perfect, you cannot be too cautious in preventing Errors and Miſtakes.

OBSERVATION IV.

The *Plane* upon which the *Scales* of the *Balance* are at reſt, or in *Æquilibrio*, ought to be perfectly Horizontal, and exactly upon a Level; for if the *Scales* do not reſt upon one and the ſame *Plane*, but that on the contrary one of them is depreſſed and the other elevated, they will not

not in that Caſe be in *Æquilibrio*; notwithſtanding they might be ſo when they were both upon the ſame Horizontal *Plane*; but that which is depreſſed will overbalance that which is elevated, nor will the *Balance* readily reſtore itſelf to an Horizontal Poſition; becauſe the Preſſure which compelled one of the *Scales* to deſcend, remains impreſſed a conſiderable time after it is down; let therefore your *Scales* be gently brought to the ſame *Plane*, that you may find whether or no they will be in *Æquilibrio*.

Of the STATERA ROMANA *commonly called the* STEEL-YARD.

Although what I have ſaid of the *Balance*, might be ſufficient to illuſtrate the Nature, and Properties of this *Machine*; yet as it differs in its Conſtruction from the *Balance*, I ſhall, (to prevent the Confuſion and Perplexity that might ariſe from their different Form) ſubjoin ſomething particularly relating to it. Let us look back to *Fig.* 11. where the right Line A, G, C, repreſents the Beam or *Brachia* of the Steel-yard, whoſe longeſt *Brachium* is G, C, and its ſhorteſt A, G; G being the *Axis* or Center of Motion. Let the Proportion between A, G, and G, C, be as 1 to 10; now if the *Weight* ſuſpended at A weighs 10 ℔, and that ſuſpended at C, weighs but one ℔, they will be in *Æquilibrio*. For according to what was laid down in the laſt of the two Mechanical *Axioms*; (*viz.*) *that unequal* Weights *will* æquiponderate *when ſuſpended at Diſtances that are in a reciprocal Proportion to their* Weights; it muſt follow, that as A, G, is but a tenth part of the *Brachium* G, C, and the *Weight* ſuſpended at C being but a tenth part of the *Weight* ſuſpended at A, that their *Weights* and *Diſtances* being thus in a reciprocal Proportion to one another they will *æquiponderate*. Some will have it that this *Æquilibrium* is produced by the ſmaller *Weight*'s having ten times more Motion and Velocity, as it deſcribes a Circle ten times greater than the larger *Weight*; for, as we have ſaid elſewhere, the farther a Point is removed from its Center, the greater Circle will it deſcribe; ſo that if any *Weight* be ſituated at 10 *Feet* from the Center of Motion, it deſcribes a Circle ten times greater, and goes through ten times the Space, that a *Weight* which is but one *Foot* from the Center does in the ſame time; thus the *Velocity* of the ſmaller is equal to the *Gravity* of the larger *Weight*.

We have ſaid enough of the Properties of the *Steel-yard*, let us now proceed to conſider the Conſtruction of it, as it is repreſented *Figure* 13. We muſt firſt then look upon the Right Line A, B, C, as the Fundamental Line of the whole *Machine*: The Diſtance between A and B, being the ſhorteſt *Brachium*, and that between B and C, the *longeſt*; you may ſuppoſe the Proportions of them to be in what *Ratio* you pleaſe; but in this Caſe the *Brachia* are to one another as 1 to 5. The *Fulcrum* of the *Steel-yard* may be conſtructed after this manner: Let the Diſtance between A and B be divided into 5 equal Parts; from B, the Center of the

Steel-yard raiſe the perpendicular B, D, upon the Right Line A, C; and upon the Line B, D, ſet off towards D, $\frac{2}{7}$ of the Diſtance between A and B; let the Perpendicular B, D, be continued downwards as far as E, to the length of $\frac{1}{7}$ of the Diſtance between A and B, ſo that the whole Line D, E, may be equal to the Diſtance between A and B. From the Point E, upon E, D, extend a Perpendicular on the Right and Left to the Points G and F, each of them equal to $\frac{2}{7}$ of the ſame Diſtance, and compleat the two Squares E, F, H, Q, and E, G, I, Q: From G and F, with the prickt Lines G, E, and F, E, deſcribe the Segments or Arches H, E, and E, I; this done, the lower Part of the Inſtrument will be formed. Now to conſtruct the upper Part, let the two Perpendiculars D, M, and D, N, be produced to D, E, equal to $\frac{1}{7}$ of the Diſtance between A and B; let them be continued to L and K to the Length of $\frac{2}{7}$ *minus* $\frac{1}{7}$ of the aforementioned Diſtance. Then from L and K deſcribe the Arches P, N, and M, O, with the prickt Lines K, N, and L, M; and thus you will have the upper Part of the *Steel-yard* conſtructed. As for the Head or Button, it cannot be wrought after a better or more convenient Faſhion than what I have drawn in the *Figure, (viz.)* If in the Circle S, U, T, X, Z, whoſe Diameter going through the Center is $\frac{1}{7}$ of the Diſtance between A and B you make ſmall Mouldings or Roundings S, Z, S, U, U T, T a a: The *Axes* R and Y are the Height of $\frac{1}{7}$ of the aforeſaid diſtance, and are made with an Edge that nearly touches the Right Line A, C; you will have the thickneſs of the longeſt *Brachium* if from C to ff you take $\frac{11}{17}$ of the ſame diſtance I have ſo often mentioned, and if from ff and C you draw the Right Line, ff, I, and C, P; in ſhort, the Right Line 5, c c, being produced through the middle between them, it will give this *Brachium* the Reſemblance of a *Rhomboides* in its *Orthographical Figure.* In ſhort, you muſt take the *Axis* or Handle D, d d, equal to treble the Line A, B; and as for the three Ornaments that are commonly upon the *Brachia* and *Axis* of this Inſtrument, they muſt be referred to the Fancy or Diſcretion of the Workman; but for ſuch as are not Artiſts, the *Scenographical Figures* I have drawn, may ſufficiently inſtruct them. I have nothing more to ſay upon this Head, except it be to ſhew you a way of dividing the longeſt *Brachium*, which is done by equal Parts, calculated for the Examination or Determination of the ſmalleſt *Weights* that are uſed. I have ſaid above that in our Example the ſhorteſt *Brachium* A, B, was to the longeſt *Brachium* B, C, as 1 to 5; therefore upon the *Brachium* B, C, you muſt diſtinguiſh the Diſtances or Parts with ſmall Lines or ſuitable Numbers, beginning to reckon the Diſtances from the Center of Motion B, and going on towards C; all theſe Parts or Diſtances may be ſubdivided into any Number of ſmaller Parts, that ſhall be deemed proper or neceſſary. The *Counter* or *Running Weight* which hangs by a *Ring*, and ſlides along the *Brachium*, weighs ſometimes one ℔, ſometimes 10 ℔ and 100, or more or leſs according to the ſize of the *Steel-yard*, the

uſe

uſe of which muſt appear evident to you from what I have been ſaying, and all the Obſervations that can be made upon it are founded upon the reciprocal Proportion of *Weights*, and their *Diſtances* from the Center. But ſince *John Buteo*, and others have ſpoken largely upon this Head, I ſhall conclude this Chapter with ſome Obſervations that are in ſome ſort neceſſary, for the right conceiving the Nature and Uſe of this *Machine*.

OBSERVATION I.

You muſt reckon the *Diſtances* upon the *Steel-yard* from that Point where it hangs and moves round freely, and the Points by which the *Weights* on either Side are ſuſpended.

OBSERVATION II.

Several *Weights* hanging at ſeveral Diſtances on the longeſt *Brachium* of the *Steel-yard*, may *æquiponderate* with a ſingle *Weight* ſuſpended from the ſhorteſt. To do this it is required, that the Product of that *Weight*, multiplied by its Diſtance from the Center, be equal to the Sum of the Products of all the other *Weights*, each being multiplied by its Diſtance from the Center.

OBSERVATION III.

That it is upon the ſame *Principles* with the *Steel-yard*, that the deceitful *Balance* is founded; which cheats by the Inequality of the *Brachia*.

OBSERVATION IV.

Of two *Weights* which ſeem to be, and are in reality in *Æquilibrio*, the *heavieſt* bears always ſuch Proportion to the *lighteſt*, as the *longeſt Brachium* does to the *ſhorteſt*. From whence you may obſerve that the *lighteſt Weights* ſeem to weigh as much as the *heavieſt*, which they do in appearance only, by means of their reciprocal *Diſtances* from the Center. Hence you may perceive, that for Bodies to be of equal *Weight*, and to *æquiponderate*, or be in *Æquilibrio*, are different Things. From which it follows, that if a Body twice as *light*, is at twice the *Diſtance* from the Center as a Body twice as *heavy*; or that if a Body a thouſand times *lighter*, is a thouſand times more *diſtant* from the Center than a Body a thouſand times *heavier*, they will be in *Æquilibrio*.

CHAP.

CHAP. XII.

The Ancient and Modern Liquid and Dry Meaſures carefully reduc'd to the Weights.

THE Collection that we have made of all the *Weights* which are uſed in almoſt all the Diſtricts of the World, and which we have treated of in the Tenth Chapter of this Book, with the utmoſt Exactneſs and Brevity the Subject would admit of; leads us now to conſider the *Liquid* and *Dry Meaſures* in *Ancient* and *Preſent* Uſe, and to reduce them to the *Weights*; conceiving that it will be a Work not wholly unuſeful to the *Pyrotechnician*, or others who voluntarily apply themſelves to the Study of the *Mechanicks:* But here both Reaſon, and the order of Things, require us to aſſociate and compare the *Meaſures* with the *Weights*, becauſe we frequently confound them together, and indifferently make uſe of both, without diſtinguiſhing between their different kinds. But before we enter upon this we muſt premiſe the following Obſervation, *(viz.)*

That both *Liquid* and *Dry* things vary infinitely with regard to *Weight*; which does not only ariſe from the Diverſity of their *Species*, but we find it alſo in one and the ſame *Specie*; ſo that *Water* does not only differ in *Weight* from *Wine*, from *Oil*, from *Milk*, from *Beer*, from *Brandy*, and from other *Liquids*; but we find alſo that there is an Inequality of *Weight* between *Water* and *Water*, *Wine* and *Wine*, *&c.* Again, we find that *Wheat* is heavier than *Wheat*, *Rye* heavier than *Rye*, *Oats* than *Oats*, *Barley* than *Barley*, and ſo on. Since then Things of one and the ſame *Specie* agree ſo little within themſelves, it can be no Difficulty to conceive, that they will greatly differ in *Weight* from one another, though with regard to *Meaſure* they may be equal, which you muſt always ſuppoſe. I muſt therefore deſire you would keep in mind, what I have already ſaid of the mutual *Ratios* of *Metals*, *Minerals*, *&c.* And ſince it is impoſſible to aſcertain the particular and exact Proportion of any *Liquid* or *Dry Things* to others of different *Species*, I ſhall here only ſubjoin ſome general Obſervations, and Experiments that have been made, to clear up this *Intricacy*: And Firſt,

That *Sea Water* is naturally heavier than any kind of *Freſh Water:* That of the different ſorts of *Freſh Water*, *Rain Water* is the lighteſt. Moreover that there is a great Inequality of *Weight* between *River*, *Spring*, *Well*, *Pond*, *Rain*, *Snow*, and *Ice Water*, and all ſorts of *Water* whether *Hot* or *Cold.*

Again, *Water* weighs heavier at one Seaſon than at another. Furthermore, *Water* will weigh in a certain Proportion near the Place from whence it iſſues out, and in a different Proportion after it has run ſome diſtance

diſtance from it; and if you obſerve the *Weight* of *Water* before it is frozen, you will infalliby find it varied after it is thawed; to illuſtrate this; Experience evinces, that *Ice* is lighter than *Water*, by the *former's* ſwimming on the Surface of the *latter*.

I ſhall deſignedly paſs over ſeveral ſorts of *Water* of different Colours, Taſtes, and Odours; nor will I take notice of ſuch kinds of it as are Glutinous, Bituminous, Aluminous, Sulphureous, or Salt; nor dwell upon thoſe that inebriate and diſturb the Brains of Perſons who drink of it. I ſhall likewiſe be ſilent with regard to ſeveral Oily Springs, one of which *Pliny* deſcribes in his xxxi Book, Chap. 11. near *Soli* a City in *Cilicia*; *Theophraſtus* relates a Spring of the ſame ſort to be in *Ethiopia*; *Solinus* ſpeaks of another in his Chap. xxiii; and *Philander* makes mention of another in his *Remarks* on Chap. iii, Book the viii, of *Vitruvius*; but theſe I ſhall paſs over, as well as ſeveral others, whether the Accounts given of them be true or falſe, the latter of which they commonly are. I find nothing of this kind worthy our Obſervation, except what *Caſſiodorus* ſays Book iv. on the Variety, in the Letter ſent by *Theodoric* firſt King of the *Oſtrogoths* to the Earl *Apronian*, (viz.) *That Waters iſſuing out towards the Eaſt and South, are clear, ſweet, and very wholeſome, by reaſon of their lightneſs; but that on the contrary thoſe that flow towards the Weſt and North, are too cold, groſs and unwholeſome.* *Solinus* relates ſomething of this kind, in ſpeaking of the River *Himera* (*viz.*) *That this River varied its Taſte as it changed its Climate, being bitter as it flowed towards the North, and ſweet when it bent its Courſe towards the South.* And doubtleſs the Diverſity of Soils through which *Water* flows may not only have an Effect upon the *Taſte* of it, but upon the *Weight* of it likewiſe, by making it lighter or heavier than when it firſt iſſued out of its Source. But to ſpeak one Word in general of Oily Springs, we may conclude they are much lighter than any others. If you are deſirous of being perfectly informed of the Nature of Springs and Waters, conſult *Ariſtotle*, *Seneca*, *Pliny*, *Cato*, *Varro*, (where he treats of Country Affairs) *Averroes*, *Palladius*, *Columella*, *Vitruvius*, *Frontinus*, *Boccace*, and many others, who will fully ſatisfy you upon this Head. I only thought myſelf obliged to ſay thus much, to ſhow the infinite Variety as to *Weight*, between Things of one and the ſame kind in particular, and between one another in general.

All ſorts of *Wine* are lighter than *Water*, but as they differ very much from one another they weigh differently; for ſo far are the *Wines* of *Falernia*, *Crete*, *Spain*, *France*, *Italy*, *Hungary*, *Turkey*, *Wallachia*, and ſeveral others from agreeing with one another in *Weight*; that on the contrary *Cretan Wine* differs from *Cretan*, and *Falernian* from *Falernian*; and theſe in general are lighter or heavier than the others we have mentioned. They likewiſe weigh variouſly at different Seaſons of the Year; in ſhort, the newer any *Wine* is the heavier it will be, and the older it is, the lighter.

Oils are lighter than either *Water* or *Wine*, as appears by their Property of ſwimming on the Surface of thoſe two Liquids, though never ſo much incorporated and mixed with them: but the different Specifick Gravities of *Oil* and *Oil* are ſtill more remarkable, for *Oil* of *Olives*, *Almonds*, *Wallnuts*, *Linſeed*, *Turnips*, and all that are made by a Preſs or any Engine of that nature, are much heavier than *Oils* extracted by *Alembicks*, *Stills*, *Matraſſes*, and ſuch like Chymical Veſſels that are more artificial.

In ſhort, all diſtilled *Waters*, *Spirits* and *Eſſences*, prepared after the ſame manner with *Oils*, weigh leſs than ſuch *Oils*, let them be what they will; and theſe likewiſe differ very much in *Weight* from one another. I ſhall not here enumerate an infinite Number of other *Liquids*, whoſe Specifick Gravities you may at your Leiſure examine. This Reſearch I ſhall leave to thoſe, who have more Time to devote to their Curioſity; as for me, I have but little enough left, to treat on Subjects which are much more uſeful and neceſſary.

All ſorts of *Grain* (as I have already ſaid) vary infinitely with regard to *Weight* when of one and the ſame *Kind*, and from one another when of different *Species*; ſo that it is difficult to aſcertain any thing, as to the mutual *Ratio* they bear to one another. However, I ſhall inſert what I have diſcovered by Experiments. I ſay then, that *Wheat* is heavier than *Rye*, *Rye* than *Barley*, and *Barley* than *Oats*; though their ſeveral Grains frequently vary as to *Size* and *Weight*. Now many Cauſes may be aſſigned for this Variety, whereof the Richneſs and Fertility of Soil is none of the leaſt; for it is highly probable that fat Ground contributes greatly to a fine Crop; becauſe of its natural Moiſture, which is better able to nouriſh its Fruit, than a dry hungry Piece of Ground, that has not wherewithal to cheriſh what it was naturally ſcarce able to bring forth.

The Second Cauſe to which it may be attributed, is the various Climates and Regions, and the different Situation of Fields and Grounds in the ſeveral parts of the Earth: as *Virgil* has it *Georg.* lib. 1.

Hic ſegetes, illic veniunt felicius uvæ:
Arborei fœtus alibi, atque injuſſa vireſcunt
Gramina.

In *Engliſh* thus,

This ground with *Bacchus*, that with *Ceres* ſuits:
The other loads the Trees with happy Fruits.
A fourth with Graſs unbidden decks the Ground.

Dryden.

And truly this matter deſerves our Conſideration, inaſmuch as we are aſſur'd by Merchants, who are the moſt experienced in this Branch

Branch of Trade, that the *Amſterdam Mudde* of Poliſh *Wheat*, or of any of its circumadjacent Provinces, weighs 150 lb; that the ſame *Meaſure* of *French Wheat* weighs 180 lb; of *Sardinian*, 220 lb; of *Sicilian*, 224 lb; of *Beotian*, 230 lb; and of *African Wheat*, 236 lb; Hear now what *Vitruvius* ſays upon this Subject, Lib. VIII. and Cap. III.

The Variety of the Fruits of the Earth, ſuch as the Canes and Reeds of Syria *and* Arabia, *and the ſeveral ſorts of Odoriferous Herbs, and Aromatic Trees,* &c. *all of ſo different a Nature; is owing to the Variety of Climates and Regions. This Diverſity of Climates does not only influence the Vegetable World, but affects likewiſe the Animal World in as various a manner; and proceeds from the Inclination, or Paralleliſm of the Earth, and the Conſequents of its Oblique Situation,* (viz.) *the different Degrees or Portions of Heat diſtributed to the ſeveral Regions of the Earth, which are by that means endued with particular Properties.*

Again; the difference between Grain is owing to the Variety of Seaſons; for continual Rains, and thick cloſe Weather, will naturally make Corn poor and light; it being in ſuch a caſe impoſſible for it to arrive at compleat Maturity, for want of that genial Warmth, which is neceſſary to effect it.

It has not been without ſome ſecret Myſtery, that the Husbandman has carefully obſerved the proper times for Sowing his Ground; he knows what Seed to ſow when the Moon is in the Encreaſe; what in her Wane; what to ſow when her Horns are ſharp-pointed; and what, when ſhe ſhines out with her full and borrowed Luſtre. They are well acquainted with the different Situations of the Heavenly Bodies; their Riſing and Setting; and with every thing elſe, that may prove hurtful to the Harveſt, and ruin their Hopes, at the very Inſtant they commit them to the Boſom of all-bearing Mother Earth. *Virgil* very elegantly warns them upon this head in the Book I before quoted.

Ante tibi Eoæ Atlantides abſcondantur,
Gnoſiaque ardentis decedat ſtella Coronæ;
Debita quam ſulcis committas Semina, quamque
Invitæ properes anni ſpem credere terræ.
Multi ante occaſum Maiæ cæpere: ſed illos
Expectata ſeges vanis eluſit ariſtis.

In *Engliſh* thus,

But if your Care to Wheat alone extend,
Let *Maja* with her Siſters firſt deſcend,
And the bright *Gnoſian* Diadem downward bend:

Before you truſt in Earth your future Hope;
Or elſe expect a liſtleſs, lazy Crop.
Some Swains have ſown before, but moſt have found
A husky Harveſt from the grudging Ground.

Dryden.

From all this we may conclude, that it is impoſſible to aſcertain exactly the different Specifick Gravity of *Grain* and *Seed*. I could ſay much more to prove the Incertitude of this Matter, but ſhall forbear ſpeaking any farther concerning it. I ſhall only here inſert the Teſtimony of *Merſennus*, to confirm the Truth of what I have here ſaid. Speaking of this Subject in the Preface of his Book of *Meaſures, Weights*, &c. he tells us, " That having weighed all the Sorts of *Grain* " and *Seed* uſually ſold in *Paris*, he could hardly find two Grains of " ſame *Specie*, that exactly anſwered to one another, which rendering " his Attempt uncertain, he gave it over; and that beſides their being " naturally different from one another in *Size* and *Weight*, they are ſub- " ject to ſuch Alterations by accidental Moiſture and Dryneſs, and by " the Evaporation of their finer Particles, that it is impoſſible to aſcer- " tain the Specifick Gravities of *Grain* or *Seeds*; and that this Incer- " titude extends in ſome degree to all natural Bodies.

Secondly, In order to reduce *Liquid Meaſures* to the *Weights* which are in preſent uſe, we will, in the Sequel of our Diſcourſe, ſuppoſe, that the *Roman Menſural Pound* was equal to 10 *Unciæ* of the *Ponderal Pound*, or that they were to one another as 10 to 12; the *Ponderal Pound*, (as we have already ſaid) containing 12 *Unciæ* or *Ounces*, and each *Ounce* 612 *Roman Grains*, and conſequently the whole *Pound* muſt be 7344 *Grains*. By reducing this *Pound* to the other of 16 *Ounces* (as has been done by ſeveral modern *Pyrotechnicians)* we mean that the *Ounce* of this, or $\frac{1}{16}$ of it, ſhould contain 576 *Grains*; but theſe Grains will not be of equal *Weight* with the *Roman Grains*, theirs being lighter than ours; ſo that 612 *Grains* of the *Roman Ounce* are equal to but 536 *Grains* of our *Ounce*; and thus our Pound weighing 9216 *Grains*, is heavier than the *Roman Pound* by 2784 of its own *Grains*; conſequently the *Roman Ponderal Pound* weighed 6432 of our *Grains*, which we have ſaid from *Merſennus* in his Co-equation of the *French* and *Roman Pound*. As to the modern *Roman Grains*, we here ſuppoſe them to be equal to the *Ancient* (though we are not aſſured of that) and we have likewiſe reduced the Ounce of our Pound to an Equality with the *French* Ounce, becauſe its *Grains* agree nearly with the Weight of pick'd Barley-corns; according to the old Example and Practice of the *Greeks* and *Romans*, as well as of the *Hebrews*, who firſt made uſe of them.

Thirdly, When in ſpeaking of the *Meaſures*, we ſhall ſay that ſuch a *Meaſure* weighs ſo many *Pounds* or *Ounces*; whether they belong to the Country where the *Meaſure* is uſed, or to any City or Country in *Europe*

rope that may be mentioned, thoſe *Pounds* or *Ounces* may be eaſily reduced to what *Weights* you will; provided you have recourſe to the Method obſerved in the general Circular *Table*, the Uſe of which I have already taught you; or if you keep in Mind the mutual Proportions of *Weights*, which we have amply diſplayed in the Tenth Chapter of this Book.

The Liquid and Dry Meaſures of the Ancient Romans.

DOLIUM was a kind of Jar, or Earthen Veſſel, which the *Ancients* ſunk into the Ground to keep Wine; it contained 1 ½ *Culeus*, that is, 2400 ℔ *Menſural*, and 2000 ℔ *Ponderal* of *Rome*; but of our *Weight* 1395 ℔, 13 *Oun.* 2 *Dr.* and 2 *Den.*

CULEUS was a Leathern Veſſel, which held 20 *Amphoræ* of Liquids, which is 1600 ℔ *Menſural*, (witneſs *Fannius* and *Columella*,) and 1333 ℔; 4 *Oun.* of *Roman Weight*; and of ours 930 ℔, 1 *Oun.* 1 *Dr.* and 8 *Gr.*

MEDIMNUS was a *Dry Meaſure*, which held 6 *Modii* or 2 *Amphoræ*; that is, 160 ℔ *Menſural*, or 133 ℔, and 4 *Oun. Roman Weight*, and 93 ℔, 7 *Dr.* and 8 *Grains* of our *Weight*. It held 144 ℔ of Wheat, *Roman Meaſure*; and *Columella* tells us, they had another *Dry Meaſure* amongſt them, which held 10 *Modii*, from whence it was called DECIMODIUM.

They had moreover a third *Dry Meaſure*, more capacious than the two former, which they called TRIMEDIMNUM, becauſe it held three *Medimni*, or 18 *Modii*, or 6 *Amphoræ*, or 480 ℔ *Menſural*, or 400 ℔ *Ponderal* of *Rome*, or 279 ℔, 2 *Oun.* 5 *Dr.* and 1 *Den.* of our *Weight*.

HYDRIA was a great Pitcher to carry Water, and held 1 ½ *Amphora*, according to *Villalpandus* upon *Geneſis*; that is, 120 ℔ *Menſural*, or 100 ℔ *Ponderal*, or 69 ℔, 12 *Oun.* 5 *Dr.* 1 *Den.* of our *Weight*.

CADUS of the ſame Dimenſions with the *Hydria*, according to the Teſtimony of *Fannius*, and held 108 ℔. of Wheat. This (he ſays) was the true *Dry Meaſure*.

AMPHORA, or QUADRANTAL, (witneſs *Cato*, *Fannius*, *Columella*, *Volutius*, *Metianus*, and ſeveral others) held 2 *Urnæ*, and weigh'd 80 ℔ *Menſural*, or 66 ℔, 8 *Oun. Ponderal*; or 46 ℔, 6 *Oun.* 3 *Dr.* 1 *Den.* and 16 *Gr.* of our *Weight*. This was a *Dry Meaſure* amongſt the *Romans*, and held 72 ℔ of Wheat. *Merſennus*, in his Reduction of this *Meaſure* to the *Pariſian Pound*, ſays, that 72 ℔ *Roman*, are equal to 50 ℔, 4 *Oun. Pariſian*, by which he means that the *Roman Quadrantal* held ſo many *Pounds* and *Ounces* of Wheat. This would be very true if theſe 72 ℔ *Roman* were *Ponderal*; but as Authors conclude them to be *Menſural*, therefore as 72 ℔ *Menſural* are equal but to 60 ℔ *Ponderal*, it can be equal to but 41 ℔, 14 *Ounces* of *Paris*; which

we deſigning to make uſe of in this Chapter, you muſt take particular Notice of it in the Sequel of our Co-equations. Perhaps (which I do not remember to have read) the *Romans* had two ſorts of the *Pound* to weigh and meaſure *Liquids* only, and another for the uſe of *Dry things* only *(viz.)* the *Ponderal Pound.* The Veſſel of a *Roman* Cubic Foot, which is ſaid to have held 80 ℔ *Menſural* of Water, was equal to the *Amphora. Dioſcorides* however will have it, that the *Amphora* held but 52 ℔ of Vinegar and 80 ℔ of Wine. *Galen,* on the contrary, ſays, that the *Amphora* held 72 ℔ of Oil, 80 ℔ of Wine, and 108 ℔ of Honey. *Merſennus* aſſures us, that he found (upon making the Experiment) that the *Roman* Cubic Foot, ſuch as the *Congialis* of *Villalpandus,* weighed 74 ℔ of *Paris Weight*; but there are thoſe who differ from him upon this Article.

The ſame Author lays it down for a certainty, and will have it (by the Obſervations of *Gaſſendus)* that the *Roman Amphora* held 55 ℔ and 14 *Oun.* of Water of *Pariſian Weight*; ſince the *Congius,* which is $\frac{1}{8}$ of the *Amphora,* holds (according to him) 7 ℔ *minus* $\frac{1}{4}$ of an *Ounce* of Water; from whence we may plainly diſcover that theſe 80 ℔ *Roman,* which formerly filled the *Roman Amphora,* were of the *Ponderal* kind. But we ſhall leave this to the Diſcuſſion of thoſe who have more time to ſpare than we have, and ſhall now proceed with our *Meaſures* in the Order we began.

The URNA or URN was (according to *Cato)* a *Liquid Meaſure* of half the Capacity of the *Amphora*; but it was ſometimes uſed to meaſure *Dry things,* and, according to what *Villalpandus* ſays, it held 1 $\frac{1}{2}$ *Modius,* or 4 *Congii,* or 40 ℔ *Menſural,* or 33 ℔, 4 *Oun. Ponderal,* and of our *Weight* 23 ℔, 3 *Oun.* 1 *Dr.* 2 *Den.* and 8 *Gr.*

The MINA was equal to the *Urna.*

The MODUS, if we may believe *Fannius,* was properly a *Dry Meaſure,* of $\frac{1}{6}$ of the *Medimnus,* and $\frac{1}{3}$ of the *Amphora*; this held exactly 24 ℔ *Roman* of Wheat. Now as to *Liquids,* (here we are chiefly to ſuppoſe Wine and Water, which agree the neareſt in *Weight)* it is certain that the *Romans* uſed but one *Meaſure* for them, which (as we have already ſaid) they called the *Menſural Pound*; as a *Liquid Meaſure,* it held 26 ℔, 8 *Oun. Menſural,* or 22 ℔, 2 *Oun.* 5 *Dr.* 1 *Den.* and $\frac{1}{2}$ *Gr. Ponderal,* and of our *Weight* 15 ℔, 7 *Oun.* 3 *Dr.* 2 *Den.* and 13 *Gr.*

The CONGIUS, which was $\frac{1}{8}$ of the *Amphora,* held 6 *Sextarii,* or 10 ℔ *Menſural,* or 8 ℔, 4 *Oun. Ponderal,* and of our *Weight* 5 ℔, 12 *Oun.* 6 *Dr.* 1 *Den.* and 8 *Gr.*

The SEXTARIUS held 2 *Heminæ,* or 1 ℔ *Menſural,* and a *Beſſis* of 8 *Ounces,* which made 20 in all; or 1 ℔, 4 *Oun.* 5 *Dr.* and 1 *Den. Ponderal*; and of our *Weight* 15 *Oun.* 3 *Dr.* 2 *Den.* and 5 $\frac{1}{2}$ *Gr.* The *Romans* had another *Sextarius,* which was called *Sextarius Ruſticus,* and was double of this.

The

The HEMINA, which was alſo called COTYLA, was a certain *Meaſure* which held 2 *Quartarii*, or 10 *Oun. Menſural*, or 8 *Oun.* 2 *Dr.* 2 *Den.* and ½ *Gr. Ponderal*, and of our *Weight* 7 *Oun.* 5 *Dr.* 2 *Den.* and 14 ½ *Gr.*

The QUARTARIUS held 2 *Acetabula*, or 5 *Oun. Menſural*, or 4 *Oun.* 1 *Dr.* 1 *Den.* and ¼ *Gr. Ponderal*, or 3 *Oun.* 6 *Dr.* 2 *Den.* and 19 *Gr.* of our *Weight.*

The ACETABULUM was a kind of ſmall Cup or Sawcer, and held 1 ½ *Cyathus*, or 2 *Oun.* 4 *Dr. Menſural*, or 2 *Oun.* 2 *Den.* and ½ *Gr. Ponderal*, and of our *Weight* 1 *Oun.* 7 *Dr.* 1 *Den.* and 9 ⅛ *Gr.*

CYATHUS was a ſmall *Meaſure* in the form of the *Acetabulum*, and held 4 *Cochlearii* or Spoonfuls; that is, 1 *Oun.* 5 *Dr.* and 1 *Den. Menſural*, or 1 *Oun.* 3 *Dr.* and 8 *Gr. Ponderal*, or 1 *Oun.* 2 *Dr.* and 23 ⅓ *Gr.* of our *Weight.*

COCLEARIUM or SPOON was the ¼ of the *Cyathus*, and was equal to 3 *Dr.* and 1 *Den. Menſural*, or 2 *Dr.* 2 *Den.* and 8 ½ *Gr. Ponderal*, and in ſhort 2 *Dr.* 1 *Den.* and 17 ¼ *Gr.* of our *Weight.*

Liquid and Dry Meaſures of the Antient Grecians.

The METRETA or METRETES of *Attica* held 3 *Roman Urns*; therefore it was equal to the *Roman Pitcher* or *Cadus.*

The ATRABA was 3 ⅓ *Roman Modii*, according to *Cato* and *Columella.*

The LACONICK METRETA was a little leſs than the *Roman Amphora.*

The ATTICK AMPHORA was equal to the *Metreta*, accord to *Fannius* and *Villalpandus.*

The AMPHOREUS was but half of the *Metreta*, according to *Agricola* and *Villalpandus.*

The CHUS or CHOAS was equal to the *Roman Congius.*

The COTYLA, which was alſo called TRIBLIUM, was equal to the *Roman Hemina.*

The OXYBAPHUM was equal to the *Roman Acetabulum.*

The MYSTRUM was of two ſorts, the greater being ⅛ of the *Cotyla*, and the *leſſer* but ¼ of the ſame.

The CHEME or CHEMA was equal to the *Roman Cochlearium*, or *Spoon.*

Obſerve here that it will be very eaſy to reduce theſe *Meaſures* to the antient Menſural and Ponderal *Pounds*, as well as to ours; they being indifferently uſed formerly, in meaſuring or weighing both *Liquid* and *Dry* Goods.

Liquid

Liquid and Dry Meaſures of the Antient Hebrews.

CHORUS, CHONER, or HOMER (as we have it in our *Engliſh* Tranſlation) held 2 *Lethecs*; it was equal to $\frac{1}{4}$ of the *Roman Culeus*, or 45 *Modii*; this was indifferently uſed in meaſuring both *Liquid* and *Dry Things*. I ſhall not give myſelf the trouble of reducing theſe *Meaſures* to the *Weights*; for any body may do it as well as I, who does but apprehend what has already been ſaid. This *Meaſure* is mentioned in the Prophet *Ezekiel*, and in the 3d Book of *Kings*, Chap. v. Ver. 2. and the 2d Book of *Chronicles*, Chap. xxvii. Ver. 5. and in St. *Luke*, Chap. xvi. Ver. 7. Some are of Opinion that this was the Load of a Camel.

LETHEC, the $\frac{1}{5}$ of the *Chorus*, held 5 *Baths* or *Ephas*, which were equal to 15 *Roman Urns*, or 22 $\frac{1}{2}$ *Modii*.

The BATH or EPHA was $\frac{1}{7}$ of the *Lethec*, and held 3 *Seah*, or 10 *Omers*; this *Meaſure* was equal to the *Roman Hydria* or *Cadus*, and to the *Attick Metreta*. *Joſephus* mentions this *Meaſure* in his Hiſtory of the *Jews*; and *Villalpandus* alſo ſpeaks ſomewhere of it.

SEAH or SATUM, the $\frac{1}{3}$ of the *Epha* or *Bath*, was two *Hins*; it was equal to 1 $\frac{1}{3}$ *Modius*, or 24 *Sextarii* of *Roman Meaſure*, according to *Villalpandus*. But *Alcanzar* will have it to have been equal to the *Modius*, by which he doubtleſs means the *Attick Modius*, that being 1 $\frac{1}{2}$ of the *Roman*. This *Meaſure* is mentioned in *Geneſis* xviii. Ver. 6. and in St. *Matthew* v. Ver. 15.

HIN was the $\frac{1}{2}$ of the *Seah*, and held 3 *Cabs*; it was equal to 12 *Sextarii* or 2 *Congii* of *Rome*; it is ſpoken of in *Exodus* xxix. Ver. 40. and in *Ezekiel* iv. Ver. 11.

OMER, $\frac{1}{10}$ of the *Epha*, was equal to 7 $\frac{1}{2}$ *Roman Sextarii*; ſomething is ſaid of it in *Exodus* xvi. Ver. 37.

CAB, the $\frac{1}{3}$ of the *Hin*, was 4 *Logs*, and was exactly equal to 4 *Sextarii*; we find this *Meaſure* ſpoken of in the 2d Book of *Kings*, Chap. vi. Ver. 25.

The LOG, $\frac{1}{4}$ of the *Cab*, held 6 *Egg-ſhells*, and was equal to a *Roman Sextarius*. Some ſay that the *Thebans* had a *Meaſure* equal to this, and that it was the ſame which *Epiphanius* calls *Aporrhyma*.

The EGG-SHELL, $\frac{1}{6}$ of the *Log*, and $\frac{1}{432}$ of the *Epha*, is thought to have held 2 *Oun.* 6 *Dr.* and 1 *Den.*

We have ſaid enough of the *Ancient Meaſures*; proceed we now to thoſe which are more *Modern*, and conſequently more familiar to us.

But I muſt premiſe that I do not here undertake a detail of the *Meaſures*, uſed throughout all the Kingdoms and States of the Earth. That would be an Attempt as vain as it is impoſſible. Therefore I ſhall only remark ſuch as are current in the moſt famous and beſt known Cities and Provinces in the World. I ſhall be obliged to call them by the

Names they bear in their reſpective Countries; and to conclude, I ſhall reduce them to the *Weights*, as I have already done with regard to thoſe of the *Ancients*.

Spaniſh *Liquid Meaſure.*

The BOTA or BUTT holds 30 *Robas*, each *Roba* weighing 30 ℔, it anſwers to 160 *Antwerp Stopes*; but the *Roba* is only 5 *Stopes* $\frac{1}{3}$. The *Antwerp Stope* weighs 6 ℔, and conſequently the BUTT weighs 960 ℔ of *Antwerp*.

The PIPA or PIPE weighs 30 *Robas* of 28 ℔ each.

The ROBA is 8 *Sommers*.

The SOMMER is 4 *Quartillas*, each of which weighs $\frac{1}{4}$ of the *Antwerp Stope*, and conſequently weighs 1 ℔.

The *Spaniards* have another kind of *Pipe*, of different Capacity from the abovementioned, with which they commonly meaſure *Oil* of *Olives*, it contains 40 *Robas*; but thoſe *Robas* are lighter than the others, as we have already ſaid.

Dry Meaſure of the ſame Nation.

The CAHI holds 12 *Hennegas* or *Annegras*.

The HENNEGA is 12 *Almudas*.

The ALMUDA weighs 7 ℔. 9 *Oun.* 14 *Ang.* and about 24 *Gr.* of *Amſterdam Weight*, and the *Almuda* is exactly $\frac{1}{77\frac{1}{2}}$ of the *Amſterdam Achane* or *Laſt* of Rye, that weighing, as we ſhall take Notice hereafter, 4200 ℔.

CAVESCO is $\frac{1}{16}$ of the *Amſterdam Laſt*, and conſequently weighs 262 $\frac{1}{2}$ ℔ of *Amſterdam*.

Portugueſe *Liquid Meaſure.*

The ALMUDA contains 12 *Canadas*.

The CANADA - - - - 4 *Quartas*.

The QUARTA is equal to the *Quartilla* of *Spain*, which weighs 1 ℔ of *Antwerp*, conſequently the whole *Almuda* weighs 48 ℔ of *Antwerp*.

The ALQUIER or CANTAR is $\frac{1}{2}$ of the *Almuda*, and holds 6 *Canadas*, which are 4 *Antwerp Stopes*, or 24 ℔ *ditto*. With this they meaſure *Oil* of *Olives*.

The QUARTILLA is 13 $\frac{1}{2}$ *Cantres*.

The STAR is a *Liquid Meaſure* uſed in *Algarva*, weighing 59 ℔, 10 *Oun*, 15 *Ang.* and 26 *Gr.* or thereabouts.

Dry Meaſure of the ſame Nation.

The MOI holds 15 *Fangas.*
The FANGA --- 4 *Alquiers.*
The ALQUIER --- 2 *Mejos*, which are half Meaſures.
The MEJO --- 2 *Quartas.*

Obſerve here, that 225 *Alquiers* are equal to a *Laſt* of *Amſterdam*, and conſequently that the *Alquier* weighs 18 ℔, 10 *Oun.* 13 *Ang.* and 10 *Gr.*

French *Liquid Meaſure.*

The MUID, QUARTAL, or CASQUE of *Paris*, holds 2 *Filets*, *Barriques*, or *Barrels.*

The FILET holds 18 *Seſtieres.*
The POT or QUART --- 2 *Pintes.*
The PINTE --- 2 *Chopines* or *Hemines.*
The CHOPINE --- 2 *Demi-Seſtiers.*
The DEMI-SESTIER --- 2 *Poſſons.*

From all this it follows, that the *Muid* of *Paris* contains 288 *Pintes*; and this it does, by an Order of *Lewis* XIII. But, in purſuance to the Orders of *Henry the Great*, it ought to contain 300 *Pintes.* Now it will be very eaſy to equalize theſe two, by taking away 12 *Pintes*, which ought to be allowed for the Lees of Wine. Hence you may readily know the Weight of a *Tunn* of Wine. For, as by the Obſervations of *Merſennus*, it appears that the *Pinte* weighs 2 ℔, it will follow that the *Tunn* or *Muid*, which contains 288 of thoſe *Pintes*, will weigh 576 ℔. But if we admit of the Lees, it will weigh 600 ℔ over and above the Weight of the Veſſel itſelf, which is not to be reckoned. *Merſennus* has deſcribed the Form and Size of the *Muid* after this manner in Prop. IV. of his Book of *Meaſures*, &c. " It has the reſemblance of a *Cylinder*, " or rather of a double *Cylinder* truncated, with equal Baſes, from " whence this Veſſel is more capacious or broader in the Middle than " towards the Ends; its Length (ſays he) or interiour Height, is 2 " *Feet* and 10 *Inches*, and in the Middle it is 2 $\frac{1}{3}$ *Feet*, and towards " the Bottom or Baſes 2 *Feet* only.

The *Caſque* or *Muid* of *Paris* holds 78 *Stopes* of *Antwerp*, and ſometimes 77, that is, 312 *Pints*, or 308: It weighs 468 or 462 ℔ of *Antwerp*; ſince (as we have already ſaid) the *Stope* weighs 6 ℔, the *Pint* which is $\frac{1}{4}$ of it ought to weigh 1 $\frac{1}{2}$ ℔; and from this we may eaſily determine the Proportion between the *Pariſian* and *Antwerpian Pound.*

They have another *Liquid Meaſure* in *France*, which the *French* call a PIPE; this holds 2 *Muids* of *Paris*, and conſequently weighs 1200 ℔.

Dry Meaſure of the ſame Nation.

The MUID, or GREAT MUID holds 2 *Tonneaux* or *Tuns*, or 12 *Seſtiers*.

The TONNEAU is ½ the *Muid* or 6 *Seſtiers*.

The SESTIER is $\frac{1}{12}$ of the *Muid*, and $\frac{1}{6}$ of the *Tonneau*, and is divided into 2 *Mines*.

The MINE is 2 *Minots*.

The MINOT contains 2 other ſmall *Meaſures* commonly called *Boiſſeaux* or *Buſhels*.

The BOISSEAU or BUSHEL, according to *Merſennus*, holds 16 ℔ of Wheat, when it is heaped up without ſhaking or ſqueezing it down. The Heap, (or what is above the Rim of the *Meaſure*) according to the ſame Author, weighs 3 ½ ℔; thus when the *Boiſſeau* is ſtriked there will remain 12 ½ ℔ in it. Suppoſe now that the *Muid* contains 96 *Boiſſeau*, we may naturally conclude that ſuch a *Muid* full of Wheat would weigh 1536 ℔.

The ſame *Merſennus* aſſures us he found by Experiment, that there are 860 Grains of Wheat in the *Ounce* of a *Pound*, taking them promiſcuouſly from any Heap or Parcel without picking or chooſing; conſequently the *Pound* will contain 13760 of thoſe *Grains*, and the *Boiſſeau* when heaped up 220160 *Grains*, but if ſtriked but 172000 only.

The *Boiſſeau* or *Buſhel*, according to the Orders of *Lewis* the XIII. *L.* 1. *Titre* 10. ought to contain 18 ℔, 6 Ounces, and 8 Scruples of Wheat; and in the ſame Place the great *Muid* is ordered to weigh 2640 ℔.

They have a kind of *Dry Meaſure* at *Roan*, which they there call POINSON, and which holds 13 *Boiſſeaux*.

In *Brittany* they have another, which they call a LOAD, it contains 4 *Boiſſeaux*, and 10 of thoſe *Loads* make a *Pipe*, which is 600 ℔ of *Amſterdam*; 7 *Pipes* or 70 *Loads* anſwering exactly to the *Amſterdam Laſt* of Rye.

Italian *Liquid Meaſure.*

BRENTA or AMPHORA is properly a *Liquid Meaſure*, uſed by the *Romans* at this Day; it contains 96 *Boccales*, and is divided into 13 ½ *Robas* or *Stones* each of which weigh 10 ℔, but theſe Pounds are of 30 Ounces each. The *Brenta* is equal to 42 *Stopes* of *Antwerp*, by which means it muſt weigh 252 ℔.

BOCCALE contains 2 *Mezzoboccale*.

BARILE, BARIL or CASK is a *Tuſcan Liquid Meaſure*, which holds 20 *Italian Bottles* which they call *Fiaſco* or *Flasks*; 18 *Stopes of Antwerp* make a *Baril* which weighs 108 ℔ of *Antwerp*. As for the

Fiaſco

Fiaſco or *Flask*, it weighs 5 ℔, 6 Ounces, and 3 Drams, or thereabouts. *Item*, 3 *Barils* make a *Staar*.

STAAR is a *Meaſure* containing 54 *Stopes* of *Antwerp*, and therefore muſt weigh 324 ℔.

MOSTACHIO, or MOSTACIO is a *Candian Meaſure*, which holds 3 *Stopes* and ¾ of *Antwerp*, and weighs 22 ½ ℔.

BOTTEL is another *Meaſure* which holds 34, 35, and ſometimes 38 *Moſtachios*.

BOTTA is a *Venetian Meaſure* of 38 *Moſtachios*, which they alſo call *Zechi*, and in ſome Places *Cantari*; 76 *Moſtachios* make a *Brenta* or *Amphora*.

BIGONCIO or CONGIUS, is in the ſame Place a *Meaſure* of 4 *Quarters*. You muſt have 18 *Stopes* of *Antwerp* to fill a *Quarter*; it weighs 108 ℔, and is equal to the *Roman Barile*. The *Bigoncio* is equal to 72 *Stopes* of *Antwerp*, and weighs 432 ℔.

SECCHIO, which the *Latins* called *Hydria*, is 15 *Stopes* of *Antwerp*. This is a *Meaſure* particularly uſed by Merchants who carry on an Inland Trade; but the preceding *Meaſure* is in requeſt amongſt ſuch as are concerned in Shipping, and who cultivate a Tranſmarine Commerce.

AMPHORA, in the ſame Country, is an *Oil Meaſure*; it is 4 *Bigoncios* or *Congii*, each of them being 4 *Quarters*. This *Meaſure* is equal to 2 *Bottas*, each *Botta* 38 *Moſtacios*.

MIGLIARIO is a *Meaſure* much in Vogue throughout all *Italy*. At *Venice* it weighs 1210 ℔. At *Verona* 1738 ℔, and is equal to 8 *Brentas*, and 11 *Baſſes*: As for the *Brenta* it is divided into 16 *Baſſes*. At *Pavia* the *Migliario* weighs 1185 ℔, which are equal to 831 $\frac{55}{114}$ ℔ of *Antwerp*. At *Vincenza* it is as at *Venice*. At *Terviſa* 1117 ℔.

Beſides theſe *Liquid Meaſures*, I have been ſpeaking of, they have ſtill others, *(viz.)*

The MASTELLO, CARA, CONSI, 10 of which make a *Cara* of *Terviſa*.

The SALM is a *Meaſure* uſed in *Puglia* and *Calabria*; it makes 10 *Staars*, each *Staar* 32 *Pignateles* or *Ollules*. This *Salm* is equal to the *French Filet*, or to the half *Quartal* of *France*. It anſwers to 39 *Stopes* of *Antwerp*, and commonly weighs 234 ℔.

Dry Meaſure of the ſame Nation.

QUADRANTAL is 3 *Roman Modii*, the *Modius* 8 *Heminæ*, the *Hemina* 2 *Sextarii*. This *Quadrantal* weighs 52 ℔, and 8 Ounces, of *Amſterdam Weight*; 80 *Quadrantals* making an *Amſterdam Laſt*.

STAR is a *Sea* or *Naval Meaſure* amongſt the *Venetians*, and weighs 131 ℔ and ½; 32 *Stars* exactly anſwering to the *Amſterdam Laſt* of Rye; but 14 of them conſtitute a *Laſt* of Barley.

Again;

Again; the AMSTERDAM LAST is equal to 80 *Stars* of *Mantua*; to 32 of *Medina*; to 96 of *Pavia*; to 112 of *Florence*; to 102 of *Vincenza*; to 32 of *Zarenza*; to 48 of *Ravenna*; and to 29 of *Terviſa*.

MOSA or MODIUS is a *Venetian Meaſure*, 7 ½ of which are equal to an *Amſterdam Laſt*. In ſome other Places it is divided into 14 *Peſos*, each of which weighs 10 ℔, each *Pound* containing 30 *Ounces*; in other Places it is divided into 4 *Degalatro*, or into 16 *Seſterces* or *Sextarii*.

CORBA, among the *Italians*, is what the *Latins* formerly called *Corbis* or *Corphinus*, and in *Engliſh* may be called a *Basket*. This is a *Dry Meaſure*. At *Bologna* it is equal to the *Venetian Star*, 32 of theſe *Corbas* being equal to a *Laſt* of *Amſterdam*.

MEDIMNUS, a *Dry Meaſure* in *Sicily*, contains 6 *Modii*, and each *Modius* 16 *Sextarii* or *Seſters*. The *Medimnus* weighs 100 ℔, 8 *Oun.* and 3 *Dr.* or thereabout of *Amſterdam Weight*; ſo that 38 *Medimni* are exactly an *Amſterdam Laſt*.

Moreover the *Medimnus*, in the Iſland of *Cyprus*, is divided into 2 *Cypræ* or *Cypruſſes*, or 4 *half Cypræ*; and 40 of theſe *Medimni* are equal to an *Amſterdam Laſt*.

In the ſame Place they divide the *Modius* into 16 *Gabenes*, *Seſters* or *Sextarii*; 2 *Modii* make a *Pontick* in that Country.

MINA or MINALI is a *Dry Meaſure* at *Genoa* and *Verona*; 23 ½ of theſe *Meaſures* are equal to an *Amſterdam Laſt* at *Genoa*; but at *Verona* it will require 72.

SOMA at *Breſcia* is alſo a *Dry Meaſure*; 16 of theſe conſtitute a *Laſt* of *Amſterdam*.

SALM, a *Dry Meaſure* in *Sicily*, holds 16 *Tumanes*; it is ſometimes of two ſorts, *(viz.)* the *ſmaller* and *greater*; 10 of the *former* and 8 of the *latter* conſtitute an *Amſterdam Laſt*.

The CARA in *Puglia* anſwers exactly to the *Venetian Star*. This *Meaſure* is of two ſorts, that with which they meaſure Rye, containing 36 *Tumanes*, but of Barley it holds 48 of the ſame above mentioned. Thus the *Cara* weighs 131 ¼ ℔ of *Amſterdam*. In ſhort, 32 *Caras* of Rye and 24 of Barley conſtitute a *Laſt* of *Amſterdam*.

German *Liquid Meaſure*.

RHUTHE holds 2 ½ *Fuder*.

FUDER, in *Latin Vehes*, is 6 *Amphoræ*, which are commonly called *Ames*, at all the following Places of Upper *Germany*, *(viz.)* *Cologne*, *Worms*, *Ulm*, *Francfort* upon the *Main*, *Oppenheim*, *Wirtzburg*, *Mayance*, and at *Wirtemberg*: But in other Places it holds 10 *Ames*; as at *Heidelberg* and *Spires*; at *Vienna*, and all over *Auſtria*, 16 *Ames* or *Amphoræ* make a *Culeus*. Again; at *Falkenheim*, *Durcheim*, and at *Augſburg*, 8 *Je* or *Ames* make a *Culeus*.

OHM or AME, which the *Latins* called *Amphora*, holds 20 *Quarts*, or 80 *Meaſures*, which, in the Language of the Country, are called *Maſſen*; or 2 *Urns*, which they call *Eimer*. Thoſe who have been at *Cologne*, *Worms*, *Leipſick*, *Francfort* upon the *Main*, *Ulm*, *Oppenheim*, *Mayance*, *Noremberg*, *Wirtzburgh*, or *Vienna* in *Auſtria*, may know this. But at *Heidelberg*, and at *Spires*, they divide the *Ame* into 12 *Quarts*, and the *Quart* into 4 *Meaſures* or *Kans*. Moreover, at *Falkenheim* and *Durcheim* they divide the *Ame* into 15 *Quarts*, of 4 *Kans* each. Then at *Wirtemberg* they reckon 16 *Innes* in the *Ame*, each of which is 10 *Kans*. In *Augsburgh* 2 *Modii* or 12 *Beſontz* make an *Ame*: To conclude; in ſome other Places they reckon 60, 64, and 72 *Kans* in the *Ohm* or *Ame*.

EIMER, by the *Latins Urna*, at *Noremberg*, *Wirtzburgh*, and generally throughout all *Franconia*, is divided into 64 *Kans*; at *Vienna* in *Auſtria* into 32 *Octaves*, or 128 *Seiltem*; at *Sabone* and *Brixem* 144 *Kans* make an *Urn* or *Eimer*, and but 8 only conſtitute a *Parcede*.

The EIMER or URN in *Miſnia*, and generally throughout all High *Germany*, weighs 36 ℔: But at *Leipſick* it is 40 ℔; and is divided into 3 *Stubecken*; and again into 4 *Cantres* or *Kans*, or (as they likewiſe have it) *Maaſs*; and each of theſe *Kans* are 2 *Noſſels* or *Quarts*. The *Noſſel* is 2 *Pints* or *Heminæ*, which they call *Halb Karter*, and the *Halb Karter* is 2 ſmall *Meaſures*, which they call *Maſslein*.

MAAS or KAN, as it is called by the High and Low *Dutch*, and by the *Latins Cantharus* or *Congius*, is almoſt of the ſame Bigneſs in all the Towns in High *Germany*. We have already ſaid enough of the Subdiviſions of theſe Meaſures; let us now examine their Weight. In *Germany* the Pound is of two ſorts, the *Menſural* and *Ponderal*, as we have already obſerved; ſo that at *Leipſick* 23 *Menſural Ounces* make but 26 ½ *Ponderal Ounces*; but every where elſe in *Miſnia* 24 *Menſural Ounces* are equal to 20 *Ounces Ponderal*; that is, they are to one another as 12 to 10, or as 6 to 5, after the manner of the *Antient Romans*. This being laid down, the *Ohms* or *Ames* of *Worms*, *Francfort*, *Ulm*, *Oppenheim*, *Cologne*, *Wirtembergh*, *Mayance*, *Heidelberg*, *Spires*, *Strasburg*, *Falkenheim*, and *Durcheim*, containing 80 *Congii* or *Kans*, will be equal to the *Antwerpian Ame*, of 50 *Stopes*, which (each *Stope* being 6 ℔) weighs 300 ℔, and conſequently the *German Pot* or *Kan* muſt weigh 3 ℔, 12 *Oun.* of *Antwerp*. By this means we may readily come at the Weight of the *Eimer* or *Urn*, as well as at that of the *Fuder*, *Rhuth*, and ſmaller Meaſures, *&c.*

Again; 128 *Kans* of *Noremberg*, *Wirtzburgh*, *Franconia*, *Vienna*, and *Augsburgh*, weigh 300 ℔ of *Antwerp*, and each of them apart weighs 2 ℔, 5 *Oun.* and ½ of the ſame.

The BEER TUNN of *Lubeck* is equal to the *Ame* of *Antwerp*, 50 *Stopes* of *Antwerp* exactly filling a *Lubeck Tunn*.

Dry Meaſure of the ſame People.

The LAST, as the *Germans* call it, or as the *Latins* have it (from the *Greek) Achane*, is properly the Lading of a Veſſel or Ship. At *Hamburgh* it is 3 *Wiſpel*, each of which contains 30 *Modii*, or *Scheffel*, as they call them: Now the *Scheffel* weighs 52 ℔, 9 *Ounces*, 12 *Ang.* and 22 *Gr.* or thereabouts of *Amſterdam*; and therefore a *Laſt* of 3 *Wiſpel*, or 90 *Scheffel* or *Modii*, will weigh 4734 ℔, 3 *Oun.* 1 *Ang.* and 28 *Gr.*

Obſerve here that this *Wiſpel* is equal to 6 *Antwerpian Ames.* Again, 83 *Scheffel* of *Hamburgh* are equal to an *Amſterdam Laſt.* At *Roſtock* and *Lubeck*, 96 *Scheffel* make their own *Laſt*; but 85 of them are equivalent to the *Laſt* of *Amſterdam.* At *Stetin* in *Pomerania* 72 *Modii* or *Scheffel* conſtitute their own *Laſt*, $\frac{5}{7}$ of which is equal to that of *Amſterdam.*

SCHIFFPFUNDT is a *Sea Meaſure* much uſed by thoſe who border upon the *German Ocean*, and *Baltick Sea.* It is properly a certain part of the *Laſt*, which comes near to the *Medimnus* of the *Romans*, or to the great *Modius*, or rather to the *Trimedimnum* which we have ſpoken of already. This is equal to the *French Load*, or the *Spaniſh Cargo*, or the *Italian Carco* or *Carico.* With this they not only meaſure all ſorts of Grain, but alſo ſeveral other Species of Goods. At *Hamburgh* it is divided into 20 *Liſpfundt*, and weighs 300 ℔. At *Lubeck*, *Copenhagen*, and *Stockholm*, 20 *Liſpfundt* make a *Schiffpfundt*, which weighs 320 ℔. But I ſhall forbear ſpeaking here of the Weight and Capacity of this *Meaſure*, (it being to be explain'd hereafter) in a vaſt number of other Places where it is in uſe.

LISPFUNDT is an Aliquot Part of the *Schiffpfundt*, as may be ſeen above, and may properly be called a *Sea Meaſure.* At *Hamburgh* it weighs 15 ℔; at *Lubeck* 16 Marks, and at *Stralſund* 16 ℔.

MALTER or MOLDER does not differ very much from the *Schiffpfundt* in Weight and Capacity. It is a kind of *Land Medimnus*, which is uſed among the Merchants of certain Towns in High *Germany.* For Example; in *Miſnia* it holds 16 *Modii*, each of which weigh 20 ℔; therefore the *Malter* weighs 320 ℔ in that Place. At *Vienna* and all over *Auſtria* it is compoſed of 32 *Modii* which they call *Atchel*, or 64 *Halb Atchels* or *Spinten.* Suppoſe now that this *Modius* weighs 21 ℔ and 14 *Oun.* of *Amſterdam*, the *Malter* will weigh 600 ℔, and conſequently 6 of them would be equal to a *Laſt* of *Amſterdam.* At *Cologn* upon the *Rhine* 18 *Medimni*, or *Malters*, are equal to the ſame, ſuppoſing each of them to weigh 233 ℔, 5 *Oun.* 6 *Ang.* and 2½ *Gr.*

Liquid

Liquid Meaſure of the Low Countries.

ROEDE is a Meaſure which anſwers to the half *Culeus* of the *Romans*. At *Dort* it is 10 *Ames*.

The AME is 10 *Schrewes*, and has ſome Affinity with the *Roman Amphora*.

The SCHREWE is 10 *Stopes*; this *Meaſure* does not vary much from the *Roman Urn*.

The STOPE agrees nearly with the *Congius* of the *Romans*, and holds 2 *Kannes* or *Pots*, which in ſome Places are called *Mengel*.

The KANNE, POT, or MENGEL, does not greatly differ from the *Roman Sextarius*, and holds 2 *Pints*.

The PINTA or PINT may be properly called *Hemina* in *Latin*, it being half of the *Kanne* or *Sextarius*.

Then 10 *Ames* of *Dort* are 14 $\frac{2}{3}$ of thoſe of *Antwerp*, of 50 *Stopes*; each *Stope* weighing 6 ℔ of *Antwerp*; and the *Roede* or *Rode* of *Dort* will weigh 4400 ℔, and conſequently the *Ame* will weigh 440 ℔; the *Schrewe* 44 ℔; the *Stope* 4 ℔, 6 *Ounces*, 8 *Ang.* the *Kanne* 2 ℔, 3 Ounces, 4 Ang. and in ſhort the *Pint* muſt weigh 1 ℔, and 12 *Ang.* of *Antwerp*.

This *Roede* is again divided into 2 *Tuns*, each of them containing 500 *Stopes* of *Dort*, or 2200 ℔; to which if you add 50 ℔ for the Weight of the *Tun* itſelf, it will, when full of Wine, weigh 2250 ℔, and conſequently 2 *Tuns* will weigh 4500 ℔. Hence it is that in loading a Ship they reckon 2 of theſe *Tuns* equal to a *Laſt* of Wheat.

Again; 14 *Ames* of *Amſterdam* are equal to 10 *Ames* of *Dort*; but we muſt here obſerve that the *Amſterdam Ame* is divided into 64 *Stopes*; therefore it weighs but 314 ℔, 4 *Ounces*, 5 *Ang.* and 22 *Gr.* or thereabouts of *Antwerp*; each *Stope* weighing 4 ℔, 14 *Ounces*, 2 *Ang.* and about 10 *Gr.* In *Friſeland*, the *Ame* is 40 *Kannes* or 160 *Mengels*. At *Malines* in *Brabant* it is 80 *Mengels*; whence it appears that the *Mengel* of *Malines* is double of that of *Friſeland*, and that what they call a *Pint* at *Malines* is a *Mengel* or *Pot* in *Friſeland*; but as to the *Ame* of *Malines* or *Friſeland*, as well as of *Louvain*, *Bruſſels*, *Boiſleduc* and *Breda*, they are equal in Weight and Capacity to the *Ame* of *Antwerp*: But the *Mengel* of *Louvain* is equal to the *Maaſs* or *Kan* of the *Germans*. The *Ame* at *Bruſſels* and *Louvain* is divided into 48 *Stopes*; at *Boiſleduc* into 50; at *Leyden*, *Delf*, *Trevers*, *Fluſhing*, *Middleburgh* in *Zealand*, *Ghent*, *Bruges* in *Flanders*, and at *Liege*, it is divided into 60 *Stopes*. Again, 50 *Stopes* of *Antwerp* are equal to 54 of the *Hague* and *Ruremond*; to 72 of *Ziriczee*, and to 26 of *Neuport* and *Oſtend*. I ſhall add to all this, that 14 $\frac{1}{3}$ *Ames* of *Bruges*, *Middleburgh*, *Trevers* and *Fluſhing* are equal to 16 *Ames* of *Dort*.

Beſides,

Beſides this *Roede* which we have been ſpeaking of, they have one of another ſort at *Bruges*, which holds 2 Veſſels or *Tunns*, each of 22 *Sextarii*, or *Seſters*, each of which is 16 *Stopes*.

The TUNN of Beer throughout all *Brabant*, contains 54 *Antwerp Stopes*; but in *Flanders* 60, and ſometimes 64 *Flemmiſh Stopes*. As for the *Dutch Tunn* it is equal to that of *Brabant*, except that of *Amſterdam*, which requires 56 ½ *Stopes* of *Antwerp*. As to the reſt, I ſhall not reduce them to the *Weights*, ſince any body may do it by knowing the Weight of the *Antwerpian Stope*.

Dry Meaſure of the ſame People.

The LAST or ACHANE, when it is uſed to meaſure Wheat, is compoſed of 16 *Sea Medimni*, which the *Dutch* call *Schippont*, each of which weighs 300 ℔; therefore the whole *Laſt* weighs 4800 ℔; but when they meaſure Rye 14 *Schipponts* make a *Laſt*, each of which are equal to the former in Weight and in Capacity, conſequently a *Laſt* of Rye will weigh 4200 ℔ of *Amſterdam*. At the ſame place, they reckon 27 great *Meaſures*, which they call *Mudden*, in a *Laſt*; each of theſe *Mudden* contains 4 ſmaller *Meaſures*, which they call *Schepelen* or *Buſhels*; therefore the *Laſt* is 108 *Schepelen* or *Buſhels*. Again; they compute 29 *Sacks* in a *Laſt*, each *Sack* of 3 *Octaves*, or *Achtelingen*, as they have it. Moreover, 24 *Salt Casks*, or 21 ½ of thoſe narrow Veſſels in which Flower is ſtowed, or 15 ½ of the larger and broader of the ſame kind, conſtitute exactly a *Laſt* of Rye; again, 18 *Tunns* or Veſſels of Beer, or as many *Ames* of *Antwerp*, anſwer to the ſame thing. Now theſe two laſt, make 3 *Tunns* of Wine, but 2 *Tunns* only are reckoned equivalent to a *Laſt* of Rye; becauſe 2 of them weigh 4200 ℔ or thereabouts; for ſuppoſe that the *Quadrantal* or *Cask* of Wine weighs 500 ℔; 2 *Tunns* or 8 *Quadrantals* will conſequently weigh 4000 ℔; and 3 of the like *Tunns* or 12 *Quadrantals* full of Rye, will weigh 4200 ℔ (without reckoning the Weight of the Veſſels themſelves) each of them containing about 360 ℔ of Rye. But we muſt take notice that all ſorts of Grain do not always weigh alike; and the *Amſterdam Laſt* of Wheat has been found ſometimes to weigh 4800 ℔, and at other times but 4200 ℔; and a *Laſt* of Rye weighs ſometimes 4200 ℔, and at other times but 4000 ℔. Try a *Laſt* of Barley, and you will find that it weighs but 3400 ℔; and Oats will weigh ſtill leſs; for which reaſon it has been cuſtomary in ſome Places, to have a more capacious *Meaſure* for Oats than for Rye. Now ſince according to the Obſervations of *Merſennus* the *Pariſian Pound* contains 13760 Grains of Wheat, which Pound is 16 Grains lighter than the *Amſterdam Pound*, this latter will contain 13776 ℔, and the *Laſt* weighing 4800 ℔, will certainly contain 66,124,800 of the ſame Grains. At *Hembden* 15 ⅕ *Tunns*, of 4 *Werpen* or *Buſhels* each, conſtitute a *Laſt* of their own; but 55 *Werpen*

anſwer to a *Laſt* of *Amſterdam*. At *Antwerp* the *Laſt* is 32 *Quarters*, and the *Quarter* 4 *Buſhels*, or *Muckens*, as they call them; thus 38 *Quarters* are equal to a *Laſt* of *Amſterdam*. At *Rotterdam* 3 *Octaves* or *Eighths* make a *Sack*, and 38 *Sacks* make the *Laſt* of that Place; but 87 *Octaves* are equivalent to an *Amſterdam Laſt*.

The MUDDE, or great MODIUS, is divided at *Louvain* into 8 ſmaller *Meaſures*, called *Halſter*; 13 of theſe are equal to a *Laſt* of *Amſterdam*, as are alſo 10 ½ of *Bruſſels*, 7 of *Maeſtricht*, and 12 ½ of *Boiſleduc*. At *Ghent* the *Mudde* is divided into 6 *Sacks*, the *Sack* into 2 *Halſters*, the *Halſter* into 2 *Quarters*, and the *Quarter* into 2 *Muckens*: Now 4 of theſe *Muddes* and 7 *Halſters* make 1 *Laſt* of *Amſterdam*. At *Bruges* they call this *Meaſure* an *Hoet*, which they divide into 4 *Buſhels*, the *Buſhel* into 4 *Quarters*, the *Quarter* into 2 *Spintes*: 17 ½ of theſe are exactly a *Laſt* of that Place; but the *Amſterdam Laſt* requires 17 ½ of them. At *Ypres* 12 *Razieres* give a *Mudde*, each *Raziere* anſwers to 4 *Tunns* of that Place, and 25 *Razieres* make a *Laſt* there: Again; 75 of theſe *Razieres* conſtitute a certain great *Meaſure* called *Ikink*, which is treble of the *Laſt*. In ſhort, they reckon 24 *Razieres* to an *Amſterdam Laſt*. In ſeveral other Places of leſs note in *Flanders* the *Raziere* is divided into 4 *Awots*, the *Awot* into 4 *Pints*, and the *Pint* into 8 ℔. At *Lewarden* in *Friſeland* the *Mudde* is 2 *Lopen*; 36 of theſe are an *Amſterdam Laſt*. At *Middleburgh* in *Zealand* the *Mudde* or great *Modius*, which they call *Hoet*, is compoſed of 16 *Sacks*; which may be properly called 8 *Razieres*, 41 ½ of which conſtitute a *Laſt* of that Place, and 40 of them anſwer to that of *Amſterdam*. At *Dort* the *Hoet* is 8 *Tunns*, and 3 of theſe *Hoet* (which are a kind of *Schiffpfundt*) are exactly the *Amſterdam Laſt*.

Poliſh *Liquid Meaſure*.

BECZKA, in *Latin* DOLIUM, and in *Engliſh* a TUNN, ought (in purſuance to an Order to that Purpoſe in the Year 1565) to contain 72 *Congii*, or *Kanns*, which the *Poles* call *Garniec*. But by an Order iſſued out afterwards in the Year 1598, it is to contain but 62 *Garniec*.

The TUNN, or Beer-Veſſel of *Dantzick*, contains 180 *Dantzick Stopes*. It has been found at *Antwerp* that 180 of theſe *Stopes* make but 81 of their *Stopes*, and from thence we conclude, that the *Dantzick Tunn* weighs 486 ℔ of *Antwerp*; and a *Dantzick Stope* weighs exactly 2 ℔, 11 *Oun.* and 4 *Ang.* of *Antwerp*; and the half of it, which they call *Halb*, weighs 1 ℔, 5 *Oun.* and 12 *Ang.* From this we may infer that the *Stope* of *Dantzick* is 4 *Antwerp* Ounces, and 16 Anglicks, leſs than the *Pot* or half *Stope* of *Antwerp*. Beſides this; I know that the *Poliſh Garniec* contains about 2 *Dantzic Stopes* of Liquor; therefore the *Poliſh Tun* of 62 *Garniec* or *Congii*, is 56 *Dantzic Stopes* leſs than that of *Dantzic*; that is, that the *Dantzic Tun* contains more than that of *Po-*

land by 28 of its own *Garniec*. Let us now conclude that the *Poliſh Garniec*, weighing 5 ℔, 6 *Ounces*, and 8 *Ang.* of *Antwerp*, does not differ much from the *Roman Congius*, as we have above deſcribed it; and I firmly believe, that thoſe who firſt inſtituted the *Poliſh Garniec* deſigned it ſhould be equal to the *Roman Congius*: But as all ſublunary Things are ſubject to Revolution and Viciſſitude, as they paſs through a long Succeſſion of Years; it is no wonder that this Meaſure has varied a little from its firſt Dimenſions, and ſuffered ſome ſmall Diminution. To conclude; ſince the *Poliſh Tunn* of 62 *Garniec* weighs 334 ℔, 12 *Ounces*, and 16 *Ang.* of *Antwerp*, it will be equal to $\frac{1}{4}$ of the *Dolium*, or to 7 *Roman Amphoræ*. As to the *Weights* of the half *Garniec*, which the *Poles* call *Pulgarca*, and the $\frac{1}{2}$ of that which is called *Kwarta-garcowa*, it will be needleſs to enlarge upon them, after ſo much has been ſaid.

The OHMA of *Dantzic* holds 110 *Dantzic Stopes* of Wine, or 20 *Quarts*, reckoning the Lees; but diſallowing of them, it will be but 104 *Stopes* and $\frac{1}{2}$, or 19 *Quarts*.

WIARDO is a *Meaſure* very well known in that Country, and contains 20 *Garniec*, *Congii* or *Kannes*.

Dry Meaſure of the ſame Nation.

LASZT, or LASTE, is a Meaſure much in vogue in *Poland*, *Livonia*, *Pruſſia*, and *Lithuania*, and all the circumadjacent Provinces. It is uſed indifferently by Merchants concerned in Sea Trade, and Dealers in Inland Cities and Towns: With this, they not only meaſure all ſorts of Grain, but all manner of Merchandize both *Liquid* and *Dry*: Or at leaſt they underſtand by a *Laſzt*, a certain Quantity of any thing of a particular Weight; as for Example; the *Laſzt* of Flax or Hemp at *Dantzic* weighs 60 *Stones*, or 2040 ℔ of *Dantzic*. Again; a *Laſzt* of Hops is 12 *Schiffpfundt* or *Sea Medimni*, or 3830 ℔ of *Dantzic*. A *Laſzt* of Flower, Honey, Mead, Beer, Aſhes, Tar, and Pitch is 12 *Tunns*; but 18 is a *Laſzt* of *Salt*. As to Wheat and other Grain, the *Laſzt* almoſt throughout all *Poland* is divided into 60 *Meaſures* which they call *Korſec*; but we meet with it of very various Capacity, and very different Weight. At *Dantzic* the *Laſzt* of Rye is 15 *Schiffpfundt*, each of which contains 4 *Meaſures* which we have elſewhere called *Scheffel*, each of which holds 16 ſmaller *Meaſures* called *Matzen*. In the ſame Place a *Laſzt* of Wheat is 26 *Schiffpfundt*; but this difference muſt be allowed for the different Weight of Wheat, which is much heavier than Rye; for both of them conſiſt of 60 *Scheffel*. It has however been obſerved that the *Dantzic Laſzt* of Rye weighs 4245 ℔ of *Amſterdam*, though it weighs 5100 ℔ of *Dantzic* itſelf. For the *Schiffpfundt* weighs 340 ℔ of *Dantzic*, containing 10 *Stones* of 34 ℔ each; but the other which is of a ſmaller Kind, and contains but 20 *Liſpfundt*, weighing each 16 ℔ of *Dantzic*, is uſed in weighing all other Commodities. Again; a *Dant-*

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zic Laſzt of Wheat weighs 6440 ℔, from whence we may gather the Weight of the *Dantzic Scheffel* or *Modius*; for it being $\frac{1}{10}$ part of the *Laſzt*, it will weigh 85 ℔ with regard to Rye, and with regard to Wheat it weighs 90 ℔, 10 *Ounces*, 5 *Quart*, and $\frac{3}{4}$ *Pond. Nom.* At *Koningsberg*, and at *Elbing* the *Laſzt* weighs 6400 ℔, and conſiſts of 16 *Schiffpfundt*, each of which weighs 400 ℔, or 20 *Liſpfundt*; and 6 of theſe make 7 *Laſts* of *Amſterdam.* At *Riga*, *Revel*, and *Narva*, 12 *Schiffpfundt* of 10 *Stone*, or 400 ℔ each, conſtitute a *Laſzt* weighing 4800 ℔ of thoſe Places, and but only 4000 ℔ of *Amſterdam.*

KLODA and MACKA is a kind of *Dry Meaſure* much uſed in the Leſſer *Poland*, and Red *Ruſſia*; that is, about *Lemburg*, *Premiſlitz* or *Premiſlaw*, and *Jaroſlaw*, extending towards the *Carpathian* or *Krapakian* Mountains; it contains 4 *Modii* or *Quartes*, or 8 half *Modii* commonly called *Pulmiarek*; or into 16 *Macka*, or 32 *Pulmarek*; now at *Lemburgh* the *Pulmarek* is equal to 4 *Poliſh Garniec* or *Congii*, and the whole *Macka* to 128 of the ſame. From this it is evident, that $\frac{1}{32}$ of this *Meaſure* is equal to the *Old Roman Urna*, and conſequently that it anſwers in all to 32 *Urns*, or 1280 ℔ *Roman.* The *Macka* in *Jaroſlaw* is 160 *Congii* or *Garniec*, *(Kanns)* but at *Premiſlitz* 130 only.

CWERTNIA is a *Meaſure* which may properly be called a *Bimedimnum*; for it holds two *Medimni* or *Korzec* of *Cracow.* At *Poſna* it is 42 *Congii* or *Garniec.* At *Kaliskie* 36 *Garniec*, and the *Wiertel Kaliski*, is 14 *Congii* or *Kanns.*

KORZEC is exactly the *Medimnus* of the *Latins*; that of *Cracow* is 16 *Congii*; by which means it happens to be equal to the *Medimnus* or 2 *Amphoræ*, and anſwers to 160 ℔ *Roman.* Its $\frac{1}{4}$ part anſwers to the *Old Roman Urn*, or the *Seah* of the *Hebrews.* In *Lublin* it is 28 *Congii*, and this does not differ much from the *Old Roman Decimodium.* That of *Sandomiria*, and *Warſaw*, is 24 *Congii*, and 12 the half of them will be equal to an *Attic Amphora*, if we believe *Fannius:* And *Villalpandus* aſſures us, it will not differ much from the *Roman Hydria*, nor from the *Metreta*; moreover $\frac{1}{4}$ of this *Meaſure* comes nearly to the *Grecian Amphoreus*; and $\frac{1}{8}$ of it is not much leſs than the *Latin Modius.*

BECZKA or TUNN is the *Dolium* of the *Latins:* With this they meaſure *Dry Things* in White *Ruſſia* and *Lithuania.* This Veſſel contains in Wheat or any other Grain almoſt 2 *Salt Casks*, if heaped up and preſſed down; it weighs about 350 ℔ of our Parts: This is the *Meaſure* of *Vilna:* That of *Smolensko* is 1 $\frac{1}{2}$ of this, and conſequently weighs 525 ℔. Beſides the *Meaſures* I have already mentioned, there are ſeveral others in *Poland*, *Lithuania*, and *Ruſſia*, of leſſer Capacities; ſuch as the *Mirka*, *Szanek*, *Oſmaczka*, &c. but theſe I ſhall paſs over without farther Notice, not only becauſe they are not in ſuch general Uſe as the reſt; but alſo for fear of growing tireſome to the Reader, who is commonly fond of Brevity. I ſhall only obſerve to you once more, that the Weight of all theſe Meaſures may vary, according to the different Specifick Gravity of Grain.

Engliſh

Engliſh *Liquid Meaſure.*

The *Gallon* contains 2 *Pottles.*
The *Pottle* —— 2 *Quarts.*
The *Quart* —— 2 *Pints.*

The *Pint* weighs one ℔ of *Troy Weight* of *England,* and conſequently the *Gallon* will weigh 8 of the ſame. Now in order to know what Proportion this Pound bears to the others we have mentioned, pleaſe to turn back to what we have ſaid in the Chapter of *Weights.* Again;

8 *Gallons*	make 1 *Firkin,*	64	℔.
16 *Gallons*	—— 1 *Kilderkin,*	128	℔.
18½ *Gallons*	—— 1 *Runlet,*	148	℔.
32 *Gallons*	—— 1 *Barrel,*	256	℔.
42 *Gallons*	—— 1 *Tierce,*	336	℔.
63 *Gallons*	—— 1 *Hogſhead,*	504	℔.
126 *Gallons*	—— 1 *Pipe,*	1008	℔.
252 *Gallons*	—— 1 *Tun,*	2016	℔.

Theſe are their Strong Beer and Ale *Meaſures.* The following are for the ſame. *N. B.* All the Subdiviſions of theſe, from the *Pint* to the *Gallon,* are of the ſame Weight with thoſe of the former.

9 *Gallons*	make 1 *Firkin,*	72	℔.
18 *Gallons*	—— 1 *Kilderkin,*	144	℔.
36 *Gallons*	—— 1 *Barrel,*	288	℔.

The *Beer Gallon* in the *Low Countries* is 2 *Stopes,* except at *Amſterdam* and *Antwerp,* where it is but 1 ⅔ *Stope.*

Dry Meaſure of the ſame Nation.

A *Way* holds 5 *Quarters.*
Quarter — 8 *Buſhels.*
Buſhel —— 4 *Pecks.*
Peck —— 2 *Gallons.*

The GALLON, as we have already ſaid, weighs 8 ℔; therefore the *Way* will be 2560 ℔.

They moreover reckon 4 *Buſhels* in an *Halſter,* which is about a *Sextarius,* and 20 ½ *Halſters* make a *Laſte.*

In *Cornwal* 20 *Quarters* make a *Score.*

In *Ireland* and *Scotland* the *Buſhel* is 18 *Gallons.*

Liquid Meaſure of ſome Eaſtern *Nations.*

MATALI or MATARI a *Meaſure* in the Kingdom of *Tunis* which holds 36 *Rotules:* It anſwers to about 5 *Antwerp Stopes*; and 10 of them make an *Ame* of the ſame Place. The *Metali* of *Tripoly*, and every where elſe in *Barbary*, is 42 *Rotules*, and is equal to 7 ½ *Ames* of *Antwerp*; from whence we may conclude, that each of them weighs 40 lb of Liquor *Antwerp* Weight.

ALMA is a *Meaſure* at *Conſtantinople*, which anſwers to 1 ⅘ *Stope* of *Antwerp*; the Liquor contained in it weighs 10 lb of *Antwerp*.

DORACH or DORAG is a *Liquid Meaſure* amongſt the *Arabians*; it approaches pretty near to the *Amphora Romana*, and is divided into 8 *Johein*.

JOHEIN is divided into 6 *Kiſt* or *Aſcats*, which nearly anſwer to the *Roman Congius*.

KIST or ASCAT into 2 *Corbins* or *Heminæ*, as the *Romans* had it.

CORBIN into 2 *Keliath*, which bear ſome Affinity to the *Roman Quartarii*.

KELIATH into 2 *Caffuk* or *Arſives*, which equal the *Roman Acetabula*.

CAFFUK or ARSIVE into 2 *Cuatum*, or as the *Romans* had it *Cyathi* or *Cups*.

CUATUM into 4 *Salgerins*, which are perfectly the *Roman Cochlearii* or *Spoons*.

Johein amongſt the *Arabians* is what the *Congius* was amongſt the *Romans*, and what the *Greeks* called *Hina*; it is 1 ½ *Stope* of *Antwerp*, and conſequently the *Dorach* is 12 of the ſame *Stopes*.

ARTABA is an *Ægyptian Meaſure* which juſt anſwers to 18 *Stopes* of *Antwerp*.

COLLATHUM in the ſame Country is 6 *Antwerp Stopes* of Liquor.

SUBITHA is an *Ægyptian Meaſure*, which is equal to 5 ½ *Stopes* of the aforementioned Place.

DADIX is 4 *Stopes* of *Antwerp*.

COPHINUS is 3 of the ſame.

CHÆNIX of the *Ægyptians* and the *Antwerpian Stope* are exactly the ſame.

The MARES and PONTES are but ½ of the *Antwerp Stope*.

Dry Meaſure of the ſame People.

METRETES or METRETA is a *Meaſure* at this Day uſed all over *Greece*, it contains 12 *Choas:* 45 of theſe make a *Laſte* in that Country; but the *Amſterdam Laſte* requires 50 of the ſame.

The PERSIAN ARTABA or ATRABA is divided into 25 *Caphilæ* or *Heminæ*, or (if you will) *Hins:* 45 or 50 of theſe *Artabæ* make an *Amſterdam Laſte.* The *Ægyptian Artaba* is divided into 5 *Aporrhimes* or *Aporrhimæ*, or into 40 *Chænices*, or into 480 *Inions* or *Inia*, or (if you will) *Sextaries:* 45 *Ægyptian Artabæ* are equal to an *Amſterdam Laſte.*

TOPIN or TOPIUM in the ſame Country contains 10 *Chænices*; as does the *Ephin* 8 *Sextaries* or *Inia.*

CAPHICI is a *Meaſure* in *Barbary* which ought to contain 20 *Guibes:* 7 of theſe *Caphici* are equal to an *Amſterdam Laſte.*

DORACH or DORAG is the ſame *Arabian Meaſure* I juſt now mentioned. They divide it in the ſame manner both for *Liquid* and *Dry* Things: Thus 80 *Dorach* anſwer exactly to an *Amſterdam Laſte.*

Thus have I done with what I propoſed to ſay concerning the *Meaſures* of Capacity; which if it falls ſhort of the Reader's Expectation, I am very ſorry for it; but upon the whole I conceive that this Eſſay will not be entirely undeſerving of favour, if it be duly conſidered, that I have done my utmoſt in it; and that I have been induced to it by no other Motive, than an earneſt Deſire, of helping the *Pyrotechnician* and other *Mechanicks*, to attain ſuch a Knowledge in this Matter, as is not to be acquired but by long Study, and continual Practice.

CHAP. XIII.

Of Long Meaſure, or the Menſuration of Space.

I Shall now proceed to inſtruct you in the nature of ſeveral ſorts of *Meaſures*, which we ſhall often mention in the Sequel of this Work, when we ſpeak of the Menſuration of Lines and Surfaces; ſo that a thorough Knowledge as to what concerns this ſort of *Meaſure* will be abſolutely neceſſary. We will begin with the leaſt of them, and go on in the ſame Order and Method, as has always been obſerved by *Geometricians*, and ſhall call them by the very Names they have given them. And Firſt;

A FINGER, as it is called by the *Germans*, *Engliſh*, *Dutch* and *Flemmings*; by the *Poles*, *Palec*; by the *Latins*, *Digitus*, and by the *Hebrews*, *Esbath*, is 4 *Barley-corns* placed on one ſide each other: Now the

the *Barley-corn* is ſubdivided into 5 *Poppy Seeds*, and this is the ſmalleſt *Meaſure* that can be aſſigned to Diſtances. But *Merſennus* contradicts this, and ſays, he found that the *Seed* of a *Red Poppy* is larger than that of the *White:* He farther ſays, that 2 *Grains* of *Muſtard-Seed* touching one another, are equal to a *Line* of the *French Inch*; to which alſo 3 *Grains* of *Red Poppy Seed*, and 4 of *White*, are equal. He again tells us, that a *Grain* of *Scolopender* or *Finger-Fern Seed*, bears the ſame Proportion to a *Grain* of *Muſtard Seed*, as 1 does to 5. From whence we may allow, that a *Grain* of *Scolopender* is the leaſt of all Seeds, ſince its Diameter is contained 2 ½ Times in the Diameter of a Grain of *White Poppy Seed*. As for the ſmalleſt Grains of Sand, the ſame Author adds, that 12 of them placed in a Right Line, and touching one another, take up the Space of a *French Line* of an *Inch*. Let us hence conclude, that theſe Grains of Sand, in their utmoſt Tenuity or Fineneſs, are the ſmalleſt *Meaſure* we can think of.

The UNICA, INCH, or DIGITUS MAJOR, called by the *Germans*, *Zol* and *Daum*, contains in Length 4 *Barley-corns*, and is by the *French* divided into 12 Parts or Lines.

The SMALL-PALM, by the *Greeks*, *Doron*, and by the *Germans*, *ein Quere Handt*, and by the *Poles*, *Dlon*, ought to be 4 *Fingers* or *Digits* broad.

The Length of the Hand is what the *Greeks* called *Orthodoron*, it is exactly 11 *Digits*.

The GREAT-PALM, or SPITHAMA, by the *Greeks*, *Lychas*, by the *Hebrews*, *Tophac*, by the *Germans*, *ein Spann*, by the *Poles*, *Piadz*, and by us a *Span*; is 3 *ſmall Palms*, or 12 *Digits*, or 9 *Unciæ* or *Inches*: This *Meaſure* (as *Merſennus* ſays) *ought to be taken from the Extremities of the Thumb and little Finger, when ſtretched out to the utmoſt Extent they can be.*

The FOOT, by the *Germans*, *ein Fuſs*, or *Schuch*, and by the *Poles*, *Stopa*, ought to be 4 *Palms*, or 16 *Digits*, or 12 *Unciæ* or *Inches*. Concerning the Diviſion of the Foot, *Philander*, one of the Commentators upon *Vitruvius*, has made the following Remarks upon his IIId Chap. and IIId Book, (*viz.*) Columella, Frontinus, Iſidorus, *and ſome others, differed from* Vitruvius *in the Diviſion of the* Foot; *for all, except this Author, were for having it divided from the Beginning into* 4 Palms *or* 16 Digits; *but as this Diviſion was ſomewhat perplexed and irregular, thoſe who ſtuck to it, taking an* Aſſis *for a Foot, divided it as well as every Integer (which they commonly called* Aſſis) *into* 12 *equal Parts; one of which was called an* Uncia; *two of them a* Sextans; *three a* Quadrans; *four a* Triens; *five a* Quincunx; *ſix a* Semis, *and ſo on to to twelve, which conſtituted the* Aſſis *or* Foot. *But our Geometricians having conſidered, that the* Unciæ *anſwered to our* Inches, *rejected the former Name, and aſſumed the latter; and indeed if we compare them together, we ſhall find that* 3 Inches *make* 4 Fingers. *Obſerve here, that I do not ſpeak with regard to the Remark in*

Frontinus's

Frontinus's *Book of* Aqueducts, *where he mentions two ſorts of the* Inch, *namely, the Round* Inch *and Square* one, *and that the Rounch* Inch *is leſs than the Square* one, *by three of its own Elevenths, and that the Square is bigger than the Round one, by three of its Fourteenths.* This is *Philander*'s Opinion concerning the Diviſion of the *Roman Foot.*

What I have further to add, is that the *Roman Foot* is of various Length in different Parts of the World: In ſome Places it is of two ſorts; as for Example, *Swenterus* relates, that there are two ſorts of it in the Town of *Noremberg* (namely) the Town or Civil *Foot*, which they call *Stadt-Schuch*, which contains 12 *Unciæ* or *Inches*; and the Mechanick or Work *Foot*, which they call *Werck-Schuch*, which is but 11 of the ſame *Inches*; but this *Foot* they have divided into 12 equal Parts, which they call *Unciæ* or *Inches*, in Imitation of thoſe of which the Town *Foot* is compoſed. Now perceiving that this great Inequality of Meaſure, would perplex and confuſe us in a great many of our Operations; I had formed a Deſign of reducing the *Feet* of all the moſt famous Provinces and Cities in the World, to one that was determined, and the beſt known of all, and to compare them with that, in the ſame manner as has been done with regard to the Contents and Capacities of *Weights* and *Meaſures.* But *Matthias Dogen* anticipated my Intention, by lately publiſhing a Treatiſe of *Military Architecture*; ſo that he has eaſed me of this Piece of Trouble, and got that Palm which I propoſed to acquire as the Reward of ſuch an Attempt; therefore finding that he has acquitted himſelf very handſomely upon this Head, and that he has reduced all the *Feet* to that of *Rhynland* or *Rynland*; I ſhall only tranſcribe them from him, for the uſe of the *Pyrotechnician* and others.

If the *Rynland* or *Leyden* Foot was divided into 1000 equal Parts; the Foot of each of theſe Places would contain ſuch a Number of thoſe Parts as are expreſſed over-againſt the Name of each Place in this Table; *(viz.)* the Foot

Of *Amſterdam*	968	The Meaſure placed before the Palace.
Of *Antwerp*	909	
Of *Alexandria*	1200	
Of *Antioch*	1360	
Of *Strasburgh*	891	
Of *Babylon*	1172	
Of *Bavaria*	924	
Of *Bremen*	934	
Of the *Brill*	1060	
Of *Dort*	1050	
Of *Goeſſe*	954	
Of Antient *Greece*	1042	
Of *Copenhagen*	934	
Of *London*	968	This is uſed all over *England.*
Of *Louvain*	909	
Of *Malines*	890	
Of *Middleburgh*	960	
Of *Noremberg*	974	
Of *Paris*	1055	The Royal Foot.
Of Antient *Rome*	1000	
Of *Samos*	1200	
Of *Toledo*	867	
Of *Venice*	1120	
Of *Ziriczee*	988	

I ſhall to this add what has been remarked of the Old *Roman Foot*, namely, that it bears ſuch Proportion to that of *Rynland* as 975 does to 1000. I mean that *Roman Foot*, the half of whoſe Dimenſions we find in *Philander*, the Interpreter of, and Commentator upon, *Vitruvius*, in his Book III. Chap. III. which, he ſays, was taken from an Antique Marble, ſtill to be ſeen at *Rome* in the Gardens of *Angelus Colotius*, and anſwers pretty well to that which was found on the Monument of *Ceſtucius Statilius*, which having been a little while ago diſcovered by *James Meleghini* (one of the beſt Architects belonging to the Pope) was through his Means removed to the *Vatican* Garden.

Moreover *Merſennus* obſerves in the Margin of his firſt Book of *Meaſures, &c.* that there are two different ſorts of Meaſure of the Old *Roman* Half-Foot; one of which he ſays was taken from the old Walls of the Capitol, and is carefully preſerved in the Library at *Paris*. This (as I have often tried) when doubled does not agree with the whole *Roman Foot* which *Philander* has given us, by nearly $\frac{1}{13}$ and is $\frac{1}{40}$ or $\frac{10}{1000}$ leſs than the *Rynland Foot*; and thus this Foot is to the *Rynland Foot* as 950 is to 1000. I have farther obſerved, that this *Foot* of the Capitol is exactly the ſame with that of *Poland* (of which I have a very nice Meaſure) which Foot is likewiſe uſed in *Lithuania*. We find another Meaſure of the Half Foot, which is taken notice of by *Merſennus*, and which *Villalpandus* ſays he took from *Congius Farneſianus*. The Meaſure of the *Roman Foot* which *Philander* has given us, exceeds the double of this laſt by $\frac{6}{975}$, and its Proportion to the *Rynland Foot* is as 969 to 1000. *Merſennus* aſſures us again in the ſame Place, that the *Royal Foot* of *France* (the Meaſure of half of which he alſo gives us) exceeds the *Rynland Foot* by 6 *Lines*, or $\frac{1}{2}$ an *Inch*. But having myſelf applied the double of this Meaſure to the *Rynland Foot*, I found that the former exceeds the latter by $\frac{10}{1000}$; therefore according to my Obſervation the *French Foot* is to that of *Rynland*, as 1050 is to 1000. But we have ſaid enough of the *Foot*, proceed we now to ſuch *Meaſures* as are larger and more conſiderable.

The PALMI-PES of the *Latins*, and the PENTADORON and PIGON of the *Greeks*, which we will call the PALM-FOOT from the firſt of them, is a Meaſure that takes in the length of 20 *Fingers*, or *Digits*; that is a *Palm* and a *Foot*; and is to be taken from the Extremity of the Elbow to that of the Hand when cloſed, or the Fiſt.

The ELL, by the *Hebrews*, *Ammach*, by the *Germans*, *ein Elen*, or *Elbogen*, and by the *Poles*, *Lokiec*, is 24 *Fingers*, or 6 *Palms*, or $1\frac{1}{2}$ *Foot*, or 18 *Unciæ*. This Meaſure is taken from the Extremity of the Elbow to that of the middle Finger. In *Perſia* and *Egypt*, the Geometrical *Ell* is 6 of ours. The *Engliſh Ell* is 3 *Feet*, 9 *Unciæ* or *Inches*.

But there being ſo great a Variety in the Length of the *Ell* in different Places, as well as in that of the *Foot*; I here ſhall give you the Reduction of it to the *Rynland Foot*, as we have borrowed it from the abovementioned *Matthias Dogen*.

If

If the *Rynland Foot* was divided into 1000 equal Parts, the *Ell* of each of these Places would contain such a Number of those Parts, as is expressed over-against the Name of each Place in this Table, *(viz.)* the *Ell*

Of *Amsterdam*	2196
Of *Antwerp*	2210
Of *Dantzick*	1842
Of *Hereford*	1326
Of *Florence*	1846
Of *Francfort* upon *Main*	1760
Of *Hamburgh*	1842
Of *Leyden*	2187
Of *Lubeck*	1842
Of *London*	2904
Of *Middleburgh*	2105
Of *Noremberg*	2105
Of *Oudewater*	2190
Of *Revel*	1768
Of *Riga*	1768
Of *Toledo*	2500
The *Vara* of *Lisbon*	2662

To this I shall subjoin, from *Mersennus*, that the *Paris Ell* contains 3 *French Feet* and 7 ½ *Inches*; consequently it will bear such Proportion to the *Rynland Foot* (according to our Observations) as 3806 and $\frac{250}{1000}$ does to 1000. But, according to *Dogen*, it is as 3824 to 1000, or thereabouts. In *Poland* the *Ell* is 2 *Feet*, and this *Ell* (if our Observations are right) is to the *Rynland Foot* as 1900 is to 1000.

Besides this; *Mersennus* assures us, that the *Broccio* or *Brace* of *Florence* (which is a kind of *Ell)* bears such Proportion to the *French Foot* as 43 does to 24. But as to the *Hebrew Ell*, he makes it 1 *Foot*, 4 *Inches*, and 3 *Lines*, according to the Capitoline Measure before-mention'd.

The PACE, which the *Latins* called *Gradus*, *Gressus*, or *Passus Simplex*, the *Germans ein Einfacher Schrit*, the *Dutch een Stap* or *Trede*, and the *Poles Krok*, ought to be 2 ½ *Feet* long.

The PACE, which the *Germans* understand by the Words *ein Doppelter Schrit*, is exactly 5 *Feet*.

The ORGYA or FATHOM, which the *Germans* call *ein Klafter*, the People of the *Low Countries een Vademe*, and the *Poles Zazen*, ought to be 6 *Feet* long. *Julian* the *Ascolonite*, an excellent Architect, would have this Measure called an *Ell*.

The CANNA and REED, which the *Hebrews* called *Kennech*, is 6 of the *Hebrew Ells*. *Mersennus* mantains that this Measure contains 8 *Feet* and 1 ½ *Inch*, according to the *Ratio* between the Capitoline *Foot* and that of *France*, which (as he says) is as 130 is to 144, or as 65 is to 72, or thereabouts.

The PERCH or RODD, of 10 *Feet*, which, amongst the *Germans*, is called *ein Mess-ruhte*, or *Stange*, by the *Flemmings een Roede*, and by the *Poles Prent*, was formerly divided into 10 *Feet* by the Ancient

cient *Romans*; from whence they gave it the Name of *Decempeda*; upon which Account it was that *Cicero*, that Prince of Orators who knew ſo well how to adapt ſignificant Terms upon all Occaſions, called thoſe *Geometricians* of his time that uſed this Meaſure *Decempedatores*. Its Length is varied infinitely at preſent: As for Example; in the *Low Countries* the *Rhynlandic Perch* is 12 *Rhynland Feet*; but to render the Calculation of this *Meaſure* eaſy, and as much as poſſible to avoid Fractions, their *Geometricians* have divided it into 10 equal parts, which they call *Feet*, each of which are ſubdivided into 10 *Unciæ*. In *Poland* and *Pruſſia* the *Perch* is 15 *Feet*, or 7 ½ of their *Ells*, this is what they call *Culmenic*, but commonly *Prent*, or *Miara Chelmienska*. In the Territory of *Noremberg* it is 16 *Feet*. In the Marquiſate of *Brandenburg* 12 *Feet*. In *France* (according to *Merſennus*) 22 *Feet* make a *Perch*. In the Territory of *Ghent* 14 *Feet*, but every where elſe in *Flanders* it is 20 *Feet*. There likewiſe does the *Foot* vary, inaſmuch as in ſome Places it is 10, and in others but 11 *Unciæ*. In *England* the *Perch* is 16 ½ *Feet*, and in *Ireland* 18.

The CORD or CHAIN is a kind of *Meaſure* well known in moſt Countries, and is what the *Latins* called *Funis Chorda* and *Catena*; the *Germans* call it *ein Schnur* and *Kette*: This is what the *Romans* formerly meant by the *Arvipendium*; the *Poles* call it *Sznur* and *Weiiſysko*, with whom it is 10 *Perches*: But its Length is not always the ſame amongſt Surveyors.

The STADIUM or FURLONG, and the *Aule*, *Roſſe-lauff* of the *Germans*, and *Staia* of the *Poles*, is in Length 125 *Geometrical Paces*, or 625 *Feet*: Among the *Greeks* the *Stadium* was 125 *Paces*, and was properly the Meaſure of a *Foot Race*.

The DIAULUS was double of the *Stadium*, it being 250 *Paces*.

The HIPPICUM was 4 *Stadia* or 500 *Paces*: This was properly the *Meaſure* of an *Horſe Race*, or *Breathing*.

The DOLICHUS was 12 *Stadia*.

The SCHÆNOS was 60 *Stadia*; but in ſome Places 40, and in others but 20 only.

The MILE is a *Meaſure* well known to all the *Europeans*, and is derived from the *Latin* Word *Mille* a Thouſand, the *Roman Mile* being always compoſed of 1000 *Paces*: But this *Meaſure* varying its Dimenſions in the different Places where it is uſed, I have here inſerted a Collection of ſuch *Spaces*, as are the moſt common in ſeveral Countries, and which bear any Affinity to the Mile; that you may with the more Eaſe and Exactneſs compare the Mile of one Country with that of onother; and that you may ſee the different *Meaſures* with which *Geographers* determine the Diſtance of Places: Theſe are reduced to the *Rhynland Foot*; (which we here own to be equal to the *Roman*) the whole according to the Calculation of *Dogen*.

MILES.	FEET.
Of *Ægypt.*	25,000 called *Schænos.*
Of *England.*	5,454
Of *Burgundy.*	18,000
Of *Flanders.*	20,000
Of *France.*	15,750 called *Lieüe* or League.
Of *Germany.*	20,000 the Leſſer.
	22,500 the Mean.
	25,000 the Greater.
Of *Holland.*	24,000
Of *Swiſſerland.*	26,666
Of *Spain.*	21,270 called *Legua.*
Of the *Hirarian* Way.	15,000
Of *Italy.*	5,000
Of *Lithuania.*	28,500 called *Mila.*
Of *Moſcovy.*	3,750 called *Warſta.*
Of *Poland.*	19,850 called alſo *Mila.*
Of *Perſia.*	18,750 called *Paraſang.*
Of *Scotland.*	6,000
Of *Sweden.*	30,000

I ſhall now haſten to a Concluſion of this Book, omitting ſeveral other kinds of *Meaſure* uſed in ſurveying Land, in which the Surveyors are governed by the Cuſtom of the Country where they are employed, and which the *Pyrotechnician* has nothing to do with. I ſhall only add that the *Poliſh Acre* (which the *Poles* call *Lan Role*, the *Germans*, *Morgen* and *Jauchart*, and the *Flemmings*, *een Bunder-Landts*) is the Breadth of one of their *Chains*, or 10 *Perches* of 15 *Feet* each, or 150 *Feet*; its Length is thrice its Breadth, or 3 *Chains*, or 30 *Perches*, which are 450 *Feet*. Moreover this ſame *Acre* contains 67500 Square *Feet*. From whence it appears, that the *Poliſh Acre* is bigger than the *Old Roman one*, which they called a double Square or *Actus*, which was but 120 *Feet* Broad and 240 in Length, and conſequently contained but 2880 Square *Feet*. The *Old Roman* and *Poliſh Feet* are equal, as I have already ſhewn.

Again; let us add that 30 Square *Acres* of *Lithuania* and *Warſovia*, conſtitute a certain Meaſure or Portion of Ground which the *Latins* called *Manſio* and *Modus Agri*, that is, a Day's Journey, and Form of a Field; and which is commonly called by the People of thoſe Countries *Wloka*, and is the ſame that the *Germans* mean by *Hube* or *Huſe*. Now the Breadth of this Plot of Ground is always 4500 *Feet*, or 30 *Chains*, or 300 *Poliſh Perches*, and its Breadth is the Length of 3 *Chains* or 30 *Perches*, or 450 *Feet*; and the whole *Area* of it contains 2025000 Square *Feet*.

Again; in *Warſovia* they divide the Breadth of the *Acre* into 2 *Zagon Liras* (as they call them) each of which is 75 *Feet* Broad. Thoſe who would know more of this may conſult the Surveyors of Land, and ſuch *Geometricians* as have more to do with it than I.

To conclude: You will have the true and exact *Meaſure* of the *Rhyn-land Foot*, as well as of all thoſe reduced to it, in our univerſal *Pyrotechnical* Inſtrument, the Form and Uſe of which I ſhall give in the ſecond Part of our Artillery. Proceed we now from the Theory to the Practice of our *Pyrotechnics*, and ſet ourſelves to work, ſince this Book has ſo plentifully furniſhed us with the neceſſary Tools. Attend then to what follows.

OF THE

GREAT ART

OF

ARTILLERY.

PART *the* FIRST.

BOOK II.

Concerning the Things which are commonly uſed in Pyrotechnics, *or Artificial Fireworks.*

CHAP. I.

Of the Origin of Saltpeter: its Nature and Operations.

IT is moſt certain that ſeveral learned Perſons, and ſuch as were verſed in *Natural Philoſophy* in the early Ages of the World, were well acquainted with the Nature of Saltpeter and Salnitre. For a Proof of this we need only conſult the Sacred Writers, by whom we ſhall find it particularly mentioned, as may be ſeen in the * Fifth Book of *Moſes*, Chap. xxix. We ſhall likewiſe find it largely treated of by ſeveral Prophane Authors, of which Number is *Pliny*, who ſays a great many Things of it, *Lib.*

* Deuteronomy xxix. ver. 23. *And that the whole land thereof is Brimſtone and Salt and Burning, and that it is not ſown, nor beareth, nor any graſs groweth therein, like the overthrow of Sodom and Gomorrah, Admah and Zeboim, which the Lord overthrew in his Anger and in his Wrath.*

Lib. xxxi. *Cap.* vii. and x. as does likewiſe *Vitruvius*, *Lib.* vii. *Cap.* xi. *Ariſtotle*, *Seneca*, and *Dioſcorides Lib.* v. *Cap.* cxxii. *Philoſtratus* in the Life of *Apollonius Tyaneus*; together with a prodigious Number of others too tedious to enumerate, from whom the Truth of this Aſſertion may be proved, namely, that the Ancients were acquainted with the Properties of Saltpeter. What I have to ſay upon this Head is, that there are ſome Moderns who are firmly of opinion, that the Saltpeter uſed by the *Pyrotechnicians* in our Days, is widely different in Form and Virtue from the Nitre of the Ancients, and conſequently will have it, that ours is a new Invention, or a Diſcovery of very late Date, purely calculated for the Service of Cannon. Thoſe who entertain this Opinion are thus far ſupported by Reaſon; that we are aſſured by ſeveral That the Ancients knew of but one kind of Nitre, *(viz.)* the Mineral or Foſſil ſort, which was naturally formed without any human Art, in Places from whence they took it: And this they divided into four different ſorts, namely, the *Armenian*, the *African* (from whence the Afronitre which *Avicen* calls *Baurach* in *Arabick*) the *Roman*, and the *Egyptian*; and was called Nitre from a certain Region in *Egypt*, where it was found in great abundance. *Serapion* moreover relates that the Mines which produced Nitre, were perfectly like thoſe of common Salt, in which running Water is congealed and condenſed, and that it was no more nor leſs than a meer Stone, from whence it got the Name of Saltpeter or Stone Salt. He adds again, that Nitre was of ſeveral Colours, as white, red, ruddy, livid, or lead Colour, and of every other Tincture it was capable of: Furthermore, the Conſtruction or Form of it was various; for ſome of it was porous and ſpongey; and ſome of it on the contrary, was more cloſely compacted, ſolid, bright, tranſparent, brittle, glittering with ſmall Sparkles, and crumbled with handling. From theſe Accidents they judged of its Virtue and natural Force, the one being much more powerful than the other in its Operations. This is what I have been able to collect, from the Teſtimony of the beſt received Authors, concerning the Mineral Nitre; amongſt whom I do not find the leaſt mention made of the Artificial Nitre now uſed by us, and which we properly call Saltpeter, Salnitre, or Halinitre. But whether this Ancient Nitre is entirely loſt to us (which however *Scaliger* denies, *Exoter* in a Diſpute with *Cardan* concerning *Subtility*, Lib. xv. *Exercit.* 104. 15. beſides its being commonly ſold in *Aſia* and in *Egypt*, and according to *John Pardo* in a ſmall Town in the *Hertrurian* Field, called the Valley of *Elſa*, where it is found in great Plenty) or whether it does not reach us, it is difficult to paſs any certain Judgment concerning it, or to diſtinguiſh between the one and the other, I mean between the Old and the New, though you ſhould compare the Virtue and Qualities of the one with the Effects of the other. Nevertheleſs the learned *Scaliger* ſtrenuouſly maintains, in the Place I have already quoted, that this Ancient Nitre (if any of it is remaining) is not very

different

different from our Saltpeter, particularly if we conſider it as to the Fineneſs of its Parts which are very ſubtile and aerial. I ſhall here inſert the following Words from him, becauſe they will not a little contribute to the Proof of this Matter. *For as ſome Salt is Foſſil, ſome extracted from Sea Water, ſome from Springs, and ſome from Aſhes; or as Glaſs is produced from Stone or Flint, ſo likewiſe may a Salt be naturally generated from Nitre; and accordingly it ſprings out in Caverns, as we are told by* Pliny. *That which ſhoots out of the Surface is commonly concreted in the Form of Salt by the Heat of the Sun. But Saltpeter is ſo far from being a Foſſil Salt, as its parts are more ſubtile, than the parts of either that or Nitre; for both Salt and Nitre are not ſo univerſally conſumed by Fire, but that ſome Dregs remain after their Combuſtion; but Saltpeter is entirely abſorbed by it. Wherefore the Foſſil Salt is more terreſtrious or earthy than the Nitre of the* † Nitraria, *and this Nitre than that which ſprings out in Caverns. This Cavernous Salt is like a very fine Flower: But on the contrary muſt not this be more earthy than that, becauſe it is leſs aerial? And that more aerial than this, becauſe it is more refined in the* Nitrariæ *than in Caverns? The fineſt Particles of that which ſhoots out of the Surface are exhaled by the Sun; but in Caverns it is quite otherwiſe. Muſt not therefore the Cavernous Salt be more craſs or groſs, becauſe it is leſs refined? Juſt as green Fruits are more crude, than thoſe that are ripened, and have imbibed the Sun-beams. The Foſſil is more groſs than the Sea Salt, as well on account of its Coction or Preparation, as of its Subſtance. This is too Aqueous, and that is too Terreſtrious; and neither of them ſo ſubtile as Saltpeter. There is a Moiſture that is in ſome degree natural to Nitre; but as it is a kind of ſubtile Scum, it is entirely devoured by Fire. And even as that Camphire which burſts through the Rind or Bark of the Tree is preferable to that which is untimely taken out of the* Matrix *where it is formed; ſo that Nitre which ſprings out of the Surface is the beſt: That indeed which is generated in Furrows in the Clefts of Caverns is finer, if we conſider it purely as to its Parts; but if you will make an Allowance for the Operation of the Sun-beams it muſt be leſs pure. That which adheres to Rocks where it is dried up,* (from whence it is called *Saltpeter,*) *bears a great Analogy and Likeneſs in Nature to Nitre itſelf, but it is more Aerial, and rather inclining to the old kind of* Afronitre; *for we have frequently obſerved a kind of Luſtre of a glimmering Purple in the Shivers of Saltpeter.*

Thus by the Arguments of this great Man we ſee, that there is as much difference between Nitre and Saltpeter, as there is between a perfect and an imperfect Mineral; between one that is pure and refined, and one that is rude and groſs; between what is ſubtile and aerial, and what is earthy and craſs; in ſhort, as much as is between a Spirit and a Body. We may then conclude that Saltpeter is the nobleſt kind of Nitre. That the ſort in uſe with us, was not well known to the Ancients we ſhall

† By *Nitraria* you are to underſtand a Place where Nitre is refined or perfected either by the *Sun* or by *Fire*.

call *Pliny* to witneſs, not to mention ſeveral others who would do the ſame: For he openly and plainly calls that Salt which was naturally formed, on the Surface of Rocks, and in Caverns and deep Cavities of the Earth, the *Flower* and *Scum* of Nitre, and Saltpeter or Stone Salt: A little of this is ſtill found in ſome Places, and in others none at all: It is generally met with upon old Walls and Ruins which are expoſed to the Wet; but particularly in Cellars and Vaults, where Wine is kept, and in many other ſubterraneous Places which are cool and damp: It nearly reſembles white Froſt, or pure Flower, or fine Sugar, and is as white as Snow: The Virtue of this is very conſiderable, as I myſelf have ſometimes experimented. If you would prepare this Salt by the Rules of our Art, it muſt be granulated into ſmall Corns, and you will ſee how exactly it will aſſume the Form of the ancient Nitre which *Pliny* ſpeaks of, and which *Scaliger* deſcribes above. But as it has been impoſſible to get ſufficient Quantities of this, to anſwer the continual Demand there has been of it, for the Service of ſo many Wars, which have been in Agitation for ſo long a time paſt; and preyed upon the fineſt Inheritances of Princes, and waſted before our Eyes, the greateſt part of the moſt powerful Empires, and moſt noble States of the Univerſe; Men have been obliged to ſeek out a new ſort, to ſupply the Defect of the Old; which being with much Labour and Induſtry taken from the Bowels of the Earth, it is purified, and waſhed ſeveral times, in order to ſeparate all terreſtrious and groſs Particles from it, and to diveſt it of its native Crudity. In ſhort, it is cleanſed, and brought to ſuch a Degree of Perfection, that it yields neither in Form nor Virtue to the Saltpeter of *Pliny*, nor even to that of *Scaliger*.

Therefore if I may have leave to declare my Sentiment as to this Point, I ſhall (to remove all manner of doubt) inſiſt upon it, that *Scaliger* meant no other Saltpeter, or Salt condenſed into a ſtony Conſiſtence, than that whoſe Uſe, artificial Preparation, Origin, *&c.* is familiarly known to us, and which we ſhall ſufficiently treat of in ſome of the Chapters of this Book. It is not a ſufficient Objection againſt us to ſay, that our Salt does not grow naturally and of its own accord, like that of *Pliny* which ſprings out of the Surface of Rocks, and fills up the Clefts of Caverns, and the Apertures and Creviſes of old Buildings, where it is condenſed, concreted, or petrified in little Furrows; for as Art is the very Ape of Nature, and ſince ſhe imitates her in every thing ſhe is capable of; it muſt not be thought ſtrange if we with a little of her Aſſiſtance, and a large Portion of our own Induſtry, attain to the Perfection of her Productions, and (if I may ſo ſay) exceed by far her moſt perfect and elaborate Works. Do we not ſee a vaſt Number of Maſterly Performances exhibited by excellent Artiſts, after a long and aſſiduous Labour, which cannot poſſibly be imitated by Nature, though ſhe were to exert her Power to the utmoſt? We may then conclude that our *Pyrotechnic Salt*, which bears down all before it, and forces its way every where, is very like the

Salt-

Saltpeter of the *Ancients*, or in a Word, that they do not in the leaſt differ from one another. For if ſo it be, that the Nitre of the *Ancients* was or is a Foſſil, I am inclined to think it was much of the ſame Nature with the Matter or Earth from whence we extract our Saltpeter; which if it be prepared according to our following Method, I may venture to affirm, that it will in every reſpect correſpond with the natural Saltpeter, and by repeated Purgations, may become more pure and exquiſite. In rectifying common Salt, and refining of Sugar, they are always fineſt after the laſt Operation. But notwithſtanding what I have been ſaying I ſhall prove by a plain Argument, that the Opinion of thoſe who believe our *Pyrotechnic Salt* to have been newly invented, is not only abſurd but falſe likewiſe; inaſmuch as ſeveral creditable Authors ſo highly and often commend the Inventor of *Gun-powder*; but ſometimes ſpeaking of him in another Strain they load him with a thouſand Maledictions, and deteſt his pernicious and abominable Invention: It is not that they accuſe him of having diſcovered a kind of Saltpeter till then unknown, for the Ruin and Extirpation of Mankind; but of having hit upon a Compoſition of certain Quantities of Nitre, (which was then commonly known) Sulphur and Charcoal mixed together, and of having introduced thoſe thundering Engines of War, which they called *Cannons*, and what is worſe, of having handed this deſtructive Invention down to Poſterity. I however agree and believe, that Saltpeter was never uſed in the Compoſition of Artificial *Fire-works*, before our *Gun-powder* was found out; but in proceſs of time, and as our Days encreaſe in Experience, as well as in Number, People with Aſtoniſhment obſerved the ſtrange Properties and horrible Effects of *Gun-powder* (of which Saltpeter may be properly called the very Soul) and perceiving that Fire diſſipated and conſumed it ſo univerſally, and ſeemed to devour it with more Greedineſs than any other Matter whatſoever, they took it into their Heads, to uſe it in making Artificial *Fire-works*, and ſo have continued to do to this Day. That which *Nicetas Choniates*, and *Johannes Zonoras* relate concerning the *Grecian* Fire which was invented before the Reign of *Conſtantine Pogonatos* Emperour of *Greece*, is not very repugnant to our Opinion: But there are thoſe who aſſure us (though they are not much credited) that *Marcus Gracchus* was the Author of it, and to whom they attribute two ſorts of it, which we ſhall ſpeak of in another place, juſt as we find them taken Notice of in ſome *Arabick* Books, which are the ſame with thoſe mentioned by *Scaliger* in his *Exercit.* CXXXIII. *Lib.* XV. againſt *Cardan*; in which I obſerve, that amongſt the many combuſtible Matters they are compoſed of, Saltpeter and Oil of Nitre are not moderately uſed, but in Proportion to the reſt make up the greateſt part. This I think we may ſafely ſay, namely, that the mixing of Saltpeter with other combuſtible Ingredients is a new Invention; or elſe (as it may be too raſh to doubt of what has been ſaid by ſo many Authors of ſuch great Probity, and who lived in ſo great

Repu-

Reputation) we may conclude that it was not commonly known, and that it was concealed as an extraordinary *Secret*; which obliged *Semimaurus* (as *Scaliger* has it) to ſay, that it was perfectly miraculous, becauſe of its ſtrange and wonderful Effects. I dare not doubt but that the Ancients had their Judgment ſo far enlightened as to know that Salnitre or Saltpeter was of a very igneous Nature; for it is a very old Opinion (though to ſome it may appear new) that though Saltpeter feels cold to the Touch, and appears white to the Eye, yet that it is very full of Red Spirits, and is naturally very hot and fiery. If we wanted Teſtimony to prove this, the *Holy Scripture*, which is the pure Fountain of Truth, will furniſh us with it, by ſpeaking ſo plainly of Fiery or Combuſtible Salt, in the Paſſage we have already quoted. But what ſurprizes me the moſt is, that the old *Romans* (not to mention the *Grecians* and *Carthaginians*, who at all Times, and in all Things were their great Emulators) who were the moſt perfect and beſt verſed in Military Knowledge, of all the Nations which bore Arms in their Days; I ſay, it is ſurprizing to me, that though in their Defences and Attacks of ſo many conſiderable Places, that either owned their Power, or were beſieged by them, they made great uſe of *Fireworks*, or burning Oil (which they called *Naptha*) Sulphur, Bitumen, Pitch, Frankincenſe, ſeveral Ways prepared, Roſin, *&c.* yet never made any Account of Saltpeter, whoſe Power and Efficacy far exceeds all thoſe Things; whether it was that they preferred all thoſe Drugs to it, or that their Engineers (which I dare not advance without trembling, ſince *Lipſius* ſays, *pauca non habemus inventa ab ævo illo meliore & ſapientiore*) were Strangers to the Nature and Properties of it, and conſequently were not aware of the Service it might be of in their *Fireworks*. However, it may not be unlikely that they uſed it, though they might keep it as a great and myſterious Secret in their *Pyrotechnicks*, and never divulged it to thoſe whoſe Curioſity might lead them to inquire into the Cauſe of ſuch wonderful Effects as they ſaw or heard of. Thus as it was only known to thoſe who were immediately concerned in the Preparation of their *Fireworks*, neither *Titus Livy*, *Cæſar*, *Tacitus*, *Salluſt*, *Polybius*, *Vegetius*, nor any other Hiſtorians, ſpeak one Word of Salnitre, Nitre, or Saltpeter, in their Writings; though, amongſt the famous and great Exploits of the *Romans*, they have deſcribed their Machines, their Arms, and their *Fireworks*. It is certain that both *Greeks* and *Romans*, *Arabians* and *Egyptians*, uſed Nitre in ſeveral of their Medicinal Compoſitions, if we may believe *Galen*, *Hippocrates*, *Theophraſtus*, *Avicen*, *Averroes*, and the Writings of many other Authors. It has likewiſe been remarked in ſome Writers, that *Patrobius* a Freed-man of *Nero* ſent to *Egypt* for certain fine Sands, found near the *Nile*, which were impregnated with a great deal of Nitre, with which he uſed to whiten his Skin; and I believe it was ſomething like what *Ovid* ſpeaks of in a Diſtich, by way of Advice to thoſe of his Time who painted.

Nec

Nec Ceruſſa tibi, nec Nitri ſpuma rubentis
Deſit & Illirica quæ venit Iris humo.

He here adviſes them not to be ſparing of Ceruſe and Nitre, *&c.*

And again,

Thus ubi miſcueris radenti tubera Nitro;
Ponderibus juſtis fac ſic utrumque trahent.

This was perhaps a kind of corroſive Compoſition made of equal Quantities of Nitre and Frankincenſe mixed together, which he preſcribes for removing all Cutaneous Blemiſhes, ſuch as Marks of the Small Pox, Pimples, Freckles, *&c.*

The *Egyptians* ſeaſoned their Horſe-radiſh with Nitre, juſt as we do our common Radiſhes with Salt. The *Macedonians* mixed the Flower, with which they made Bread, with a little of the *Caliſtrine* Nitre, which was found in great quantities in the Quarries of *Clytes* in *Macedonia*; which was excellent Seaſoning, and with which they ſalted their Meat. I believe I need ſay no more to you upon this Head, and that what I have offered here, will change the Opinion you might have had concerning Saltpeter, if you before entertained any Thoughts about it that were repugnant to ours; and I hope we ſhall for the future be of one Mind with regard to this Fact, jointly confeſſing that our *Pyrotechnic Salt* was very well known to the Ancients, and that it is very like their Nitre, before its being prepared; but being refined and purified, it exactly anſwers to their Saltpeter. This being laid down, let us proceed to the Artificial Preparation of our Salt. But in the mean time, I preſume, it will not be taken amiſs, that I cloſe this Chapter with an Account of the Cauſe why Saltpeter detonates or makes a Noiſe and Sparkling in the Fire, by way of Corollary from *Scaliger* againſt *Cardan Lib.* xv. *Exercit.* 24. as follows: *Dii benefaciunt Salipetræ*, &c. *May the Gods bleſs our* Saltpeter (cries he) *which keeps from us thy dangerous and fiery Difficulties, though of itſelf it be of the moſt igneous Nature. Thou wouldſt have us believe that* Saltpeter *retains many earthy Particles, becauſe it detonates, or makes a Noiſe in the Fire: But that can never be the Reaſon, for if it was, Earth ought to detonate when heated by that Element; which it does not. Is it then the Rarity of it? which* Ariſtotle *calls* χαυώτητα and σομφότητα; *this I cannot think; for daily Experience ſhows us, that Muſhrooms are ſilent on the Fire. Is it then the Hardneſs or Solidity of its Parts joined to its Rarity? This is not likely, ſince the Pumice-ſtone has not that noiſy Quality. Some other thing muſt then be the cauſe of the Detonation of* Saltpeter *when enkindled. The Divine Preceptor in the eleventh Section of his Queſtions, ſays, That* Saltpeter

peter makes a noiſe in the Fire, becauſe it contains a great deal of Moiſture in it, which being highly rarified by Heat becomes meerly ſpirituous: It is thus I interpret πνεύματος. *It contains rather Air than Water, which being violently expanded by Fire, becomes impatient of the narrow Bounds which confined it, when cohering in a more compacted Form; and therefore burſts open its Priſon; ſo that the outward Air being greatly agitated by this Exploſion, you conſequently hear that Clamour which uſually attends the burning of* Saltpeter, *and other Things wherewith it is incorporated. Let not this appear ſtrange; for Cheſnuts, and Bay-leaves, as well as thoſe of Juniper (and I believe the* Berries *of them too) do the ſame thing, which contain much Air and little Moiſture. It is not ſo with the Pumice-ſtone, whoſe Pores are all open and pervious, and conſequently the Air in them muſt be of the ſame Tenor with the circumambient Air.*

CHAP. II.

The Method of preparing Saltpeter *from a* Salnitrous Earth.

THE Earth or Matter that is productive of *Saltpeter*, is commonly found in great Plenty, in dark, ſhady, and cavernous Places, which are equally guarded from the Heat of the Sun-beams, and from the Acceſs of Rain, or any kind of freſh Water. It is likewiſe met with in Stables and other covered Encloſures where any ſort of Cattle are kept; and alſo in ſuch Places where Men uſually diſcharge their Urine. In ſhort, it is to be found in Fields and other Scenes of Battle, where Heaps of putrified Carkaſſes lay covered with Earth: Such Places as theſe have for many Years paſt been ranſacked, where great Quantities of Saltpetrous Matter have been found, particularly in *Wallachia*, and in the *Deſarts* of *Podolia*, between the *Boh* and *Boriſthenes*: Upon which Account the *Poles* have been formerly obliged to war againſt the *Crim* and *Precopian Tartars*, and what is worſe are at this Day involved in dreadful Confuſions with the *Coſſacks*, who have rebelled againſt them. ‘ But, O God! be thou propitious to the Enterprizes of ‘ our invincible *John Caſimir*, by thy infinite Goodneſs King of *Poland* ‘ and *Sweden*; inſpire him, and conduct him in all his Undertakings, to ‘ the end that taking into his Hands the Reins of his Empire, which thou ‘ haſt lately committed to him, he may not be inclined to guide them ‘ through the Paths of Clemency and Mercy; (Ornaments much more ‘ becoming a King, than the Severity of Puniſhments;) but may his aveng- ‘ ing and victorious Arms juſtly chaſtiſe the Inſolence, and mow down ‘ the Heads of thoſe turbulent Spirits, who though always born to Servi-

'tude, yet like wild and reſtif Aſſes, have always reſiſted againſt the 'Spur, and formerly refuſed a Submiſſion to the mildeſt Laws of their 'Sovereigns; and now not contented with a Proſpect of Liberty (a Happineſs too refined for their rude and barbarous Taſte) they meditate I 'know not what Empire over others. May he extirpate the Generation 'of them, and when his juſt Severity ſhall have ſubdued them, may he 'deprive them of all Hopes of Forgiveneſs, and make them dearly pay 'for their perfidious Rebellion: In ſhort, after having heaped dead Carkaſs upon dead Carkaſs, and made diſmal Burial-Places of that vile Race, '(obliging them at once to groan under the Yoke of their own Ruin, and 'the Weight of our Earth, after the manner of the Giants whom *Jupiter* 'overwhelmed for a Crime of the like Nature) may we add the Hills of 'theſe newly-deſtroyed Carkaſſes to the old ones, whoſe faithleſs Foot-'ſteps they purſued. From theſe Monuments of Mortality and juſt Vengeance will Poſterity have ample and glorious Subject, whereon to 'yield immortal Thanks to the Heroic Virtues of ſo powerful a King, 'when they ſhall with Aſtoniſhment behold the Trophies of ſo compleat 'a Victory, infinitely ſurpaſſing thoſe famous Pyramids erected of old by 'the Vanity of *Memphis*, and which paſſed for Wonders amongſt the Ancients. From hence likewiſe, from the Putrefaction of theſe Rebels, 'may be extracted *Saltpeter*, wherewith to make thunder-imitating 'Gun-powder, the Stench of whoſe Smoke ſhall have the ſame Effect 'upon the Remains of that ungovernable Race, if ever they revive ſuch 'fatal Commotions, as the offenſive *Effluvia* of the burnt Body of one 'Bug have upon its Survivors, which, according to *Naturaliſts*, deſtroy 'or deprive them of their noxious Qualities; like theſe therefore ſhall 'they all be deſtroyed, or being diſarmed of their inveterate Untractableneſs, be obliged to live peaceably under the Yoke of the Prince, whom 'Heaven ſhall ſet over them; or elſe taking a diſtant Flight with ſuch as 'are Enemies to their Country's Quiet, and dreading the Puniſhments 'they may juſtly expect; loſe all Inclination, and never once entertain 'the leaſt Deſire of returning home again.' Theſe are the Vows, and this is the Prayer, which the Fidelity I bear to my Prince, and the Love I have for my Country, have dictated to my Pen; and which I hope the great Lord of Hoſts will bring to paſs, if he ſees it will contribute to the Glory of his Holy Name. But I forget how inſenſibly I ſtray from my Subject; let us therefore reſume it, and conſider a little on the Methods of trying the Goodneſs of *Salnitrous Earth.*

There are three ways of doing it, from which you may determine with a good deal of Certainty, with regard to the Soil from whence you would extract *Saltpeter*; and which are the moſt practiſed by Perſons concerned in this ſort of Work.

The Firſt as follows: Take a little of the Earth, which you imagine to be productive of *Saltpeter*, and put it upon your Tongue; if

it

it bites a little ſharply, it is a Sign your Labour will not be in vain; but if on the contrary it is flat and a little corroſive, I would not adviſe you to throw away your Time and Money about it.

The Second, is by making an Hole in the Earth, and throwing into it a Piece of red-hot Iron; which done, you muſt ſtop the Hole cloſe up, 'till the Iron is cold; and if upon taking it out again you find any Spots or Marks about it of a Lemon or whitiſh-yellow Colour, you need not doubt of the Goodneſs of it.

Thirdly, You may make the Experiment by throwing a little of the Earth upon burning Coals, which if it makes a noiſe or crackling and emits bright Sparkles, you may depend upon it, that it will anſwer your Purpoſe.

Having by one, or all theſe Tryals, been convinced of the Goodneſs of the Soil, whence you propoſe to extract your *Saltpeter*, dig up what Quantity you want, and let it at once be carried to ſome convenient Place. Then get a good ſtore of Wood, ſuch as Oak, Aſh, Elm, Maple, or any other hard kind of Wood, which you muſt burn, and preſerve the Aſhes. Then take two Parts of theſe Aſhes, and three of Quick Lime, and incorporate them well together, and ſet this Mixture aſide for the Uſe I ſhall hereafter mention. In the mean time get a large Tub or any wooden Veſſel wide at top; and in the Bottom of it bore an Hole of an Inch or two Diameter; let this Hole be covered with ſmall Twigs wrought in faſhion of a little Hurdle, and then ſtrew the Bottom of the Veſſel all over with clean and whole Straw, not excepting the little Hole. This Veſſel being prepared after this manner, place it ſo that a ſmall Veſſel may ſtand under it, to receive the Liquor which ſhall run from the upper one. Then begin with putting a *Stratum* or Layer of your Saltpetrous Earth in the Bottom of your Veſſel, to the Height of a Palm, or the Thickneſs of 3 or 4 Inches, which before you do this, muſt be dried a little in the Air: Then upon this Earth put a Layer of 3 or 4 Inches deep of your Compoſition of wood Aſhes and Quick Lime; and upon that, another Layer of your Earth, of the ſame Thickneſs with the former, and upon that again another Layer of your Compoſition; and ſo on alternately a Layer of Compoſition upon a Layer of Earth, and a Layer of Earth upon a Layer of Compoſition, *Stratum ſuper Stratum*, till you are come within 3 or 4 Inches of the Brim of your Veſſel, which Space you muſt leave for the Water which is to be poured upon it. This done, pour as much freſh Water upon it as you think needful; or to the Height of 3 or 4 Inches above your Ingredients; which as it penetrates and paſſes through the Maſs of the Matter, contained in the Veſſel, will diſtil Drop by Drop through the Hole in the Bottom of it, into the Recipient that ſtands under it, and you will have a *Salnitrous Lixivium* or Lye, in proportion to the Quantity of Water you ſhall have poured upon your Ingredients: If

you

you think it too little, you muſt repeat the Operation, ſo that the Water paſſing through them a ſecond time, you may have the more of the *Salnitrous Particles* which the Water will bring away with it.

This being done, pour out the Lye in your Recipient into ſome Pot or Boiler of ſufficient Capacity, and make it boil at firſt over a ſlow Fire, and after that over a ſtrong one till a third of it is evaporated or waſted; then pour in again as much of the ſame Lye as will fill up the Boiler, and let it evaporate as before, and ſo continue to do till all your Lye has undergone this Ebullition. You muſt take care to ſcum the Lye whilſt it is boiling with an Iron or Copper Scummer full of Holes. In ſhort, the Lye being thus boiled, ſcummed, and cleanſed from all its Filth, you may take it from off the Fire, and pour it into ſome Wooden Veſſel; then covering it up cloſe, let it ſtand till it is cold and ſettled, ſo that all the groſs and earthy Particles in it may ſubſide to the bottom.

After this, take the Veſſel, and, by Inclination, pour out the clear Liquor only into a Boiler, as you did before, taking great Care that none of the Sediment runs in with it; and put it again upon a hot Fire, and let it boil till it is half evaporated, or till it begins to thicken, or till putting ſome Drops of it upon a Piece of rough Marble, or an Iron Plate, it is perceived to coagulate or chryſtalize.

Then taking it from the Fire, let it cool a little, and pour it into Wooden Veſſels that are broad and ſhallow, to the height of 2 or 3 Inches only, or thereabouts. After having covered theſe Coolers with Canvas, or coarſe Cloth, let them be carried into ſome ſhady retired Place, where, after 3 or 4 Days, you will find the *Saltpeter* concreted in little Furrows, like Chryſtal, ſticking to the ſides of the Veſſels, or to little Sticks with the Bark ſtript off of them, and indifferently put into the Coolers before the Liquor was poured into them. Then carefully collect all the *Saltpeter*, and put it into any Veſſel which is proper to hold it and preſerve it dry. Then boil the *Lixivium* or Lye remaining in the Coolers over again, not forgetting to ſeparate from it the Sediment at bottom, which may be laid aſide for another Uſe.

If it happens to boil over, throw into it a little of other Lye, made of three Parts of the Aſhes before mentioned, and one of Quick Lime, in every 100 lb Weight of which you muſt diſſolve 4 lb of Roach Allum; and it will be neceſſary that you ſhould have this *Lixivium* ready by you. Thus by throwing a little of this into the Boiler from time to time, as often as the Liquor riſes, you will ſee it immediately fall, and the common Salt and Earthy Particles will precipitate to the Bottom.

The Earth remaining in your Veſſel after all the Lye has paſt through it, muſt be put into ſome covered Place, where neither the Sun-beams, Rain, nor any kind of Water, can come near it, (though it is proper it ſhould be frequented by Men or any Animals) where it may be ſcattered or ſpred to the height of a Foot. Then over this may be laid the Dung

of any kind of Cattle to the height of 2, 3 or 4 Feet. Then take all the Filth, Scum and Sediment, which you ſhall have ſeparated from your Lye, during and after its Ebullition, together with what Liquor remains, after you have extracted what *Saltpeter* you can from it after repeated Boilings (ſeparating from it the Terreſtrious Matter and the common Salt, which ſubſide, and which are good for nothing) and ſcatter or ſprinkle them over your Dunghill, and every Day throw as much human Urine upon it as you can get; by doing which, your Soil will be as much impregnated with *Saltpeter* as it was at firſt, if not more, and which you may eaſily extract after the Method we have here given.

CHAP. III.

How to clarify or refine Saltpeter.

SINCE it is a received Opinion that Gun-powder ought to hold the firſt Rank of all thoſe Things that are uſed in *Pyrotechnics*; and inaſmuch as its powerful Force, and ſupernatural Effects, cannot be attributed to any moving Cauſe which is more active or ſtrong than it ſelf; and imagining that its chief Energy conſiſts in a Separation of all groſs and ſtrange Matter from its purer Particles; I thought it not enough, barely to extract this *Salt* from a Saltpetrous Earth, but alſo to purge and cleanſe it twice or thrice, or oftner if need be, that you may have it in the higheſt Degree of Perfection; and this you may do by two Methods.

The Firſt. Be there taken as much *Saltpeter* as ſhall be thought fit, and put into a Boiler, then let there be as much freſh Water poured upon it as may be ſufficient to diſſolve it; on which muſt be poured a Quantity of that Lye, made by an Infuſion of Aſhes, Quick Lime, and Roach Allum, which we have already mentioned; let all this be boiled together till the *Saltpeter* is all diluted, and entirely reduced to a Scum or Froth. This done, let there be ready a Wooden Veſſel, of ſufficient Capacity, which muſt be placed in ſuch a manner, that another may be ſet under it, the Bottom of the uppermoſt being perforated as before, and which Bottom muſt likewiſe be covered with fine, clean waſhed Sand, to the thickneſs of 3 or 4 Inches; over which ſpread a Piece of coarſe Linnen Cloth. Then take the Liquor in the Boiler, and pour it into the upper Veſſel, which will diſtill Drop by Drop into the Recipient beneath; and being thus ſtrained through the Sand, covered with a coarſe Cloth, it will leave all its groſs and uſeleſs Particles behind. Afterwards pouring it out of the Recipient into the Boiler, let it boil again, as before, till it is ready to coagulate; then put it into broad and ſhallow Coolers, as we ſaid in the foregoing Chapter, and let it cool at leiſure

leiſure in ſome retired Place; and in two or three Days you will have your *Saltpeter* chryſtalized much purer and finer than at firſt. If you would go on to refine it, repeat this Operation ſome few times more, after the ſame manner as we have proceeded in this firſt Purgation.

The other way of refining it is thus. Put your *Saltpeter* into a Boiler, made either of Copper, Iron, or glazed Earth; then ſet it on a ſlow Fire, which muſt be quickned by degrees till all the Salt is fuſed or melted, and boils up in great Bubbles; then take a little common Sulphur well pulverized, and throw it upon the liquified *Saltpeter*, which will inſtantly take fire, and conſume all the oily and viſcous Humour, together with all the droſſy Salt which had been impregnated with the *Saltpeter* before its Clarification: This you may repeat ſeveral times till all thoſe foreign Particles are entirely conſumed. In ſhort, the *Saltpeter* being well liquified and cleanſed, you may pour it out upon poliſhed Marble, or upon Plates of Copper, Iron, or glazed Earth, and it will be condenſed to almoſt the Colour and Conſiſtence of white Marble, or of pure and perfect Alabaſter.

CHAP. IV.

How to reduce Saltpeter *to a* Flower.

THE *Saltpeter* having been refined, muſt be put into a Boiler, over a ſmall Furnace upon burning Coals; then inceſſantly blow the Fire till it arrives to that Degree of Heat, that all the Moiſture of the *Saltpeter* is evaporated in Fumes, and that it has attained a perfect Whiteneſs. But in drying it after this manner, you muſt take Care to ſtir it continually to the very bottom with an Iron or Wooden *Spatula*, leſt it ſhould return to its firſt Form. This done, pour fine, clear, freſh Water upon it, till it is covered; and when it is diluted and has acquired the Conſiſtence of a denſe Liquid, keep inceſſantly ſtirring it as quick and as faſt as you can, till all the Moiſture is evaporated *ad ſiccitatem*, and that it is all reduced to a very fine, white and dry *Flower*.

CHAP. V.

The manner of preparing Saltpeter *with the* Flower of Wall.

GET together a Quantity of that fine Flower which is commonly found upon the Surface of old Walls, that are in damp and ſubterraneous Places: You may alſo get ſome of that Salt, which frequently adheres to Lime, or the Ruins of old Buildings; which, *Peter Sardi*

ſays, he found to anſwer very well at *Bruſſels* in *Brabant*, in Book III. Chap. xxix. of his *Artillery*. You muſt firſt make a Lye of Quick Lime and common Water, which muſt be fined as uſual; then having put your *Flower* or *Saltpeter* in a Veſſel, with an Hole in the bottom of it, and ordered it in the ſame manner as we have directed in the ſecond Chapter of this Book, throw your Lye upon it, and mix it well with a *Stapula* till the *Saltpeter* is all diluted; let this Liquor drop into the Recipient that ſtands beneath, and being all drained off, pour it into a Boiler, and heat it by ſlow Degrees over a Fire; then make it boil till it has acquired a ſufficient Denſity, and that it will eaſily coagulate; then go on with your Proceſs in the ſame manner I have directed above.

There have been even ſilly Girls who have had ſome Notion of this kind of *Salt*: An Inſtance of which we have from *Valerius*, *Lib.* I. *Cap.* i. where he ſpeaks of a Diſciple of the Virgin *Emilia*, who paying her Adoration to the Goddeſs *Veſta*, had put ſome ſhreds of fine Linnen upon a Chafing-diſh, which, though the Fire in it ſeemed to be quite extinguiſhed, broke out into pure and lively Flames. Now the Reaſon he gives for it is this; (ſays he) we muſt believe that this good Lady had put Scrapings of ſome old Wall, (or Flower of Wall as we call it) into this Linnen, and laid it upon warm Aſhes, or elſe ſprinkled them over with ſome of it, which broke out into thoſe Flames, and produced that Effect; which raiſed the Wonder of thoſe who knew not the Cauſe of it.

Furthermore, it ſometimes happens that Fire takes hold of the Walls of certain Buildings with ſuch Subtility, as to aſtoniſh one, as if it were a Prodigy. This *Cardan*, (*Lib.* X. of *Varieties*, *Cap.* xlix.) attributes to the Salt, which uſually adheres to the Surface of Walls, and Ruins of old Buildings.

CHAP. VI.

How to prepare Salprotic, *or* Pulvis Fulminans.

TAKE of *Saltpeter*, two or three times clarified or refined, a certain Quantity of Pounds, to each Pound add of *Sal Armoniack* ℥ ij, and of *Camphire* ℥ ſs, and mix them all well together in ſome Braſs Veſſel; then pour upon them good *Brandy*, till they are covered with it to the height of 2 Inches. Boil them upon a quick Fire till all the Moiſture is evaporated; then taking it from the Fire, put what remains into an unglazed Earthen Pot; cover it, and hang it up, placing under it a glazed Earthen Plate or Diſh, into which you muſt carefully ſcrape a certain fine whitiſh Subſtance, very much like Flower of Wall, which will appear

pear upon the outward Surface of the Pot; you muſt continue to gather this white froſty Subſtance as faſt as it penetrates through the Veſſel that contains it. In ſhort, having got together all of it that will perſpire through the Pores of the Pot, put it carefully up in ſome dry Place till you want it.

CHAP. VII.

How to prove the Goodneſs of Saltpeter.

PUT ſome *Saltpeter* upon a Wooden Table, or ſome ſmooth Board, and ſet fire to it with a live Coal, and obſerve the Effects of it.

If in burning it makes the ſame Noiſe as common Salt does when it is thrown upon the Fire, it will be a Sign that it is ſtill impregnated with a good deal of common Salt.

If it yields a greaſy thick Scum, it is a Sign that it retains many viſcous Particles.

If after its Combuſtion there remains any Filth, or Droſs, upon the Board, it is a ſure Token that it contains a great deal of Earthy Matter. In ſhort, the more Dregs or Phlegm is left after the Combuſtion of the *Saltpeter*, ſo much the more impure and groſs muſt you judge it to be, and conſequently the leſs active.

But if, on the contrary, it breaks out into a long bright Flame divided into ſeveral Rays, and the Surface of the Board is free from any Droſs; or if it be conſumed to a pure Coal without any Scum; if it took fire without any great Noiſe, or violent Detonation; you may conclude that the *Saltpeter* is well cleanſed and perfectly well prepared.

Joſeph Furtenbach aſſures us, in his *Artillery*, that it is an infallible Sign of the Excellence of *Saltpeter*, if after the ſecond Clarification, (according to the Preſcription in the third Chapter of this Book, which is the uſual Way of doing it) it loſes 4 ℔ in 100 ℔; and conſequently after having been purified over again, according to the other Method laid down in the ſame Chapter, you will find it diminiſhed 4 ℔ of its Weight, as before.

CHAP. VIII.

The true Method of purifying Saltpeter, *and of ſeparating from it all noxious and ſuperfluous Matter; ſuch as common* Salt, Vitriol, Allum, *and all groſs and viſcous Humours.*

TAKE 2 ℔ of Quick Lime, 2 ℔ of common Salt of Verdigreaſe, 1 ℔ of *Roman* Vitriol, 1 ℔ of Sal Armoniac. Pulverize them all together, then put them into ſome ſhallow Wooden Veſſel, and pour upon them a good Quantity of Vinegar or Wine; or, for want of either of them, you may uſe clear freſh Water; and thus make a *Lixivium* or Lye, which you muſt leave to ſettle and fine of itſelf for three Days. Then put your *Saltpeter* into a Boiler, and pour as much of this Lye amongſt it as will cover it; ſet it upon a gentle Fire, and let it boil till one half of all the Liquor is evaporated; then take it from the Fire, and pour what remains gently into another Veſſel, and ſeparate from it all the Dregs and Filth which ſunk to the bottom of the Boiler. This done, let this *Saltpetrous Liquor* cool, and go on with your Proceſs, according to the Rules we have preſcribed in the third Chapter of this Book.

CHAP. IX.

How to purifie common Sulphur.

EXPERIENCE plainly evinces that not only *Saltpeter* is full of Earthy Matter; but that *Sulphur* alſo is not free from a groſs, oily Humour, which Qualities are as noxious and prejudicial, as they are common to both the one and the other of them; therefore if you would have the pure Quinteſſence of theſe Ingredients, you muſt alſo purifie *Sulphur*, in order to exalt its Nature, and make it more fiery and aerial. In doing of which proceed as follows. Melt what Quantity you want of common *Sulphur* in an Earthen or Copper Veſſel, over a ſlow, clear Fire; and, with a Spoon, gently take off all the Scum and Droſs that ſwims on its Surface; then take it off, and filtrate it through a fine Linnen Cloth into another Veſſel, ſqueezing it out pretty lightly. Thus all the Dregs and Oil of the *Sulphur* will remain in the Cloth, and you will have your *Sulphur* pure and clean after this Filtration. There are

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ſome who, after having fuſed the *Sulphur*, and taken it from the Fire, have added to it a certain Quantity of Quickſilver, and then ſtirred them about as faſt, and incorporated them together as well as poſſible, which they have continued to do till cold, that they might be the more cloſely and univerſally united; from whence we muſt believe that the Deſign of purifying it, is not only to render it more violent and active, but alſo that it may be the more volatile and ſubtile. There are others who, when their *Sulphur* is melted, mix Glaſs finely pulverized with it, and pour Brandy upon it, together with ſome Pieces of bruiſed Allum, imagining That greatly contributes to the refining of *Sulphur*.

You may know the Goodneſs of *Sulphur* by preſſing it between two Iron Plates; for if in running it appears yellow like Wax, and emits no ſuffocating Scent, and if what ſtays behind is of a reddiſh Colour, you may conclude it to be natural and excellent. It is obſerved, that Fire is ſo fond of *Sulphur*, and that reciprocally, *Sulphur* takes ſuch Pleaſure in being devoured by that Element, that if any Bits of it happen to lye about any Wood, ſo as they can feel the Heat of it, they ſeem to call it to them, and really attract it ſometimes. There is another kind of *Sulphur* which does not burn like the reſt, and is not attended with any bad Smell, but being put upon the Fire melts juſt like common Wax. This ſort of it is found in great abundance in *Ice-land* near Mount *Hecla*, and in *Carniola*; as *Libavius* relates in the firſt Part of the *Apocap. Hermet.* Now this Sulphur is commonly red, as is alſo that which is found in the Streights of *Heildeſheim*, (as *Agricola* writes, *Lib.* I. *de Effl. Terr. Cap.* xxii. from the Teſtimony of *Joh. Jonſton*, *Adm. Nat. Claſ.* IV. *Cap.* xiii.) where it is likewiſe of ſeveral Colours, as pale, yellow, and green, and generally adheres to the Surface of Stones and Rocks, and may eaſily be broken off and collected. That which is perfectly yellow is the beſt. We call that *Sulphur vivum* or *Quick Sulphur*, that has never been concerned with Fire; others call it *Virgin Sulphur*, becauſe the Women and Girls in *Campania* uſually make a kind of Paint of it to beautifie the Face.

CHAP. X.

How to reduce Saltpeter *to an* Oil.

LET there be put upon a Table, or Plank of Fir, that is well dried and planed, a certain Quantity of purified *Saltpeter*; then under the Plank or Table let there be ſet a Braſs Baſon, and under that ſome burning Coals; when the Fire melts the *Saltpeter*, you will ſee a Subſtance perfectly like an *Oil* flow from it, which will penetrate through the Wood, and drop into the Baſon that is underneath. You may continue this Operation till you have enough of this *Oil*, provided that from time to time you add freſh Supplies of *Saltpeter*.

CHAP. XI.

How to prepare Oil *of* Sulphur.

TAKE a good Quantity of purified *Sulphur*, and melt it upon a gentle Fire, either in an Earthen or Copper Veſſel. Then take of old red Tiles that have been uſed in ſome Building; but if you cannot get ſuch, take new ones that are thoroughly burnt, and have never been wet; break them into Pieces of the bigneſs of a Bean, and throw them into the liquified *Sulphur*; mix them well together till the Pieces of Tile have abſorbed or imbibed all that Liquid; then put them into an Alembick, over a diſtilling Furnace. Thus you will have a Chymical Extraction of your *Oil*, which will be excellent, very combuſtible, and proper in the Compoſition of artificial Fire-works.

ANOTHER METHOD.

Take a Matraſs (the Fig. of which you have Nº 14.) and fill about a third or fourth Part of the Belly of it with *Sulphur* finely pulverized, pour into it Spirit of Turpentine, or Oil of Walnuts, or of Juniper, till, what with the *Sulphur* and the Liquid you pour upon it, you have half filled the ſaid Matraſs; then ſet it upon hot Aſhes, and let it there continue 8 or 9 Hours, and you will ſoon after ſee that the Spirit of Turpentine will turn the *Sulphur* into a red *Oil*, which will be as fiery and combuſtible as the former.

There are thoſe who uſe the following Ingredients in the Preparation of *Oil* of *Sulphur* to make it the more igneous *(viz.)* of Sulphur 1 ℔. of Lime ℔ ſs, of Sal Armoniac ℥ iiij.

Beſides this, the *Chymiſts* have a way of preparing a certain *Oil* of *Sulphur* (which they call a Balſam) whoſe Virtues are ſo admirable, as to prevent Putrefaction in any living or dead Body; and preſerve them in ſo perfect and ſound a State, that neither the pernicious Influences of the Heavenly Bodies, nor the Corruption cauſed by the Elements, nor even that which might naturally proceed from the very Principles of them, can in any degree impair or alter the Symmetry of ſuch dead Bodies as are embalmed with it, nor of thoſe that have been anointed with it whilſt living. They prepare alſo a certain kind of Fire (as *Trithemius* tells us) with the Flower of *Sulphur* or Brimſtone, of Borax, and Brandy, which will burn many Years without extinguiſhing. There are others who have a way of preparing a Lamp filled with ſome ſuch Oil as this, which makes thoſe it gives Light to appear without Heads.

CHAP. XII.

The Method of preparing a Mixture of Oil *of* Sulphur, *with* Oil Saltpeter.

TAKE equal Parts of *Sulphur* and *Saltpeter*, and incorporate them well together, then reduce them to a very fine Powder, and let them be ſearced: Put this Powder into an Earthen Pot that has never been uſed, and pour as much White-wine Vinegar, or Brandy upon it, as will be ſufficient to cover it. Then lute up your Pot ſo cloſely that no Air can poſſibly enter in, and ſet it in ſome warm Place, where let it remain till the Vinegar is quite digeſted. Then take what remains in the Pot, and extract the *Oil* from it, with ſuch Chymical Inſtruments as are proper for the Operation.

CHAP. XIII.

How to prepare Charcoal *or* Small-Coal *for the Uſe of* Gunpowder, *and for other Uſes in* Pyrotechnics.

IN the Months of *May*, or *June*, when all ſorts of Trees are eaſily ſtripp'd of their Bark, and more ſappy than at any other time of the Year, cut down a good Quantity of *Filberd*, *Hazel*, or *Willow* Wood, of two or three Feet long, and half an Inch thick; throw aſide all their uſeleſs Branches and hard Knots: then ſtripping off the Bark, tye them up in little Bundles or Faggots, and dry them in an hot Oven: which done, put them all upright in ſome even Place, and ſet fire to them; and as ſoon as you perceive they are thoroughly lighted and inflamed, cover them up quickly with wet Earth, which ſhall have been moiſtened for that purpoſe, ſo that the Fire may have no manner of communication with the outward Air. The Flame being thus ſtifled, and totally ſuppreſſed, you will have your *Coal* pure, and entire without Aſhes. In twenty four Hours you may take it up, and lay it aſide to be uſed in ſuch Compoſitions as we ſhall mention hereafter. If it happens that you cannot get a ſufficient Quantity of *Willow* or *Hazel* to make your Coal with, you may make it of *Lime-Tree* Wood.

But if you ſhould not want any great Quantity of *Coal*, you may take Twigs of the Wood I have been mentioning, or *Juniper*, and cutting them into little Splinters, and then drying them well; put them into

an Earthen Veſſel well luted with Clay; and encompaſſing it all round, and covering it a-top with burning Coals, let it continue in that State for the ſpace of an Hour, taking care all the time to keep the Fire in an uniform Degree of Heat. This done; let it cool at leiſure, and take out your *Coal.* There are thoſe who take Pieces of old Linnen well waſhed and dried, and then burn it after this manner. The Virtues and Properties of this are not to be deſpiſed by the *Pyrotechnician.*

CHAP. XIV.

How to prepare Pulvis Pyrius, *or* Gun-powder.

THE Compoſition and Preparation of *Gun-powder* is not only very well known to ſuch as are profeſſed *Pyrotechnicians*, but likewiſe to many of thoſe who never make uſe of it but for Muſquets, Piſtols, and ſuch light Fire-arms. Nay, what is very odd, the very Peaſants in our Country have learned to make it with their own Hands, without the help of any artificial Engines, or Chymical *Apparatus.* For (and I think it will not be very improper in this Place, to make the Digreſſion) I have ſeen many of the Inhabitants of *Podolia* and *Ukrania*, whom we now call *Coſſacks*, who make their own Powder, after a Method entirely contrary to the Practice of our *Pyrotechnicians.* For Example, they put certain Quantities of *Saltpeter*, *Sulphur*, and *Charcoal* into an Earthen Pot (the due Proportions of which they have attained to by long Uſe) then pouring freſh Water upon them, they boil them over a ſlow Fire, for two or three Hours, till all the Water is totally evaporated, and that their Compoſition is become very thick; then taking it out of the Pot, they dry it in the Sun, or ſome warm Place, in a thing like a Frying-pan. They then paſs it through a Hair-ſearce, and make it into very ſmall Grains. There are others of them that pound their Compoſition, and incorporate it in an Earthen Porringer, or grind it upon ſome ſmooth poliſhed Stone; then moiſten it, and corn it, and bring it to ſuch a degree of Perfection, that it ſerves them as well as if it had been prepared by the moſt ingenious Artiſt in the World.

It will therefore be to little purpoſe to dwell upon this Article, or to give a detail of the Preparation of our *Powder*; ſo I ſhall only preſent you with ſome excellent and approved Compoſitions for the making of three ſorts of *Gun-powder.*

Compo-

Compoſition for *Cannon-Powder.*	Compoſition for *Muſquet-Powder.*	Compoſition for *Piſtol-Powder.*
1.	1.	1.
Of *Saltpeter* - 100 lb.	Of *Saltpeter* - 100 lb.	Of *Saltpeter* - 100 lb.
Of *Sulphur* - - 25 lb.	Of *Sulphur* - - 18 lb.	Of *Sulphur* - - 12 lb.
Of *Charcoal* - - 25 lb.	Of *Charcoal* - - 20 lb.	Of *Charcoal* - - 15 lb.
2.	2.	2.
Of *Saltpeter* - 100 lb.	Of *Saltpeter* - 100 lb.	Of *Saltpeter* - 100 lb.
Of *Sulphur* - - 20 lb.	Of *Sulphur* - - 15 lb.	Of *Sulphur* - - 10 lb.
Of *Charcoal* - - 24 lb.	Of *Charcoal* - - 18 lb.	Of *Charcoal* - - 8 lb.

As you pound or grind your Mixture of Cannon or Muſquet *Powder*, you may ſprinkle it gently with freſh Water only, or Vinegar, Urine, or Brandy. But if you would have your Piſtol *Powder* ſtronger than ordinary, you muſt now and then ſprinkle your Compoſition whilſt it is in the Mortar with the following Liquor; or with Water of Orange, Citron or Lemon Peel, diſtilled with an Alembic or any other Chymical Organ, and let it all be well pounded or ground for the ſpace of 24 Hours; then corn it very finely.

Now this Liquor is made of 20 Meaſures of Brandy, 12 Meaſures of Eſſence or Spirit of White-wine Vinegar, 4 Meaſures of Spirit of Nitre, 2 Meaſures of common Water of *Sal Armoniac*, one Meaſure of Camphire diſſolved in Brandy, or pulverized with Sulphur, or in ſhort reduced to an Oil, with Oil of ſweet Almonds.

In the ſecond Part of our *Artillery* I ſhall give you the *Figure* of the Hand-Mill which is uſed in making *Gun-powder*, together with a great many other Machines and Engines, which are uſually reſerved in Arſenals and Magazines of *Artillery*.

It is a ſtrange and moſt aſtoniſhing Property of *Gun-powder*, that it ſhould have a more violent Effect when corned, than when in a fine Flower or Meal; the Reaſon of which I ſhall leave to the Diſcuſſion of thoſe, who make it their particular Buſineſs to inſinuate themſelves into the wonderful Secrets of Nature. I content myſelf with having been taught by long Practice; that if in any Gun the Powder be rammed down too hard, ſo that the Corns of it loſe their Figure, or are in the leaſt pulverized, it will by that means be diveſted of much of its Force, and will not drive out the Bullet, with that Violence it would have been capable of, if it had been gently puſhed down to the Bottom of the Piece; and we have ſometimes obſerved, that its Power has been ſo far diminiſhed by this means, that it has hardly been able to overcome the Reſiſtance of the Bullet, and diſlodge it from the Piece. The ſame thing happens if Powder is wet, which being thereby deprived of its Expulſive Force, burns lazily and without Effect; ſo that if any Piece be charged with it, and you ſet fire to it, it will be ſo far from being able

to

to drive out the Ball that it will all burn out at the Touch-hole. How it comes to paſs that *Gun-powder*, by being bruiſed, and reduced to a ſoft Flower or Meal, loſes thus its Virtue and Activity; muſt be owing to the Rays of Fire, which though it be the moſt ſubtile and active of all Elements, yet is not ſufficiently fine to penetrate and enkindle at once a hard compacted Body at the very Moment it ſeizes upon it. This Aſſertion needs no Proof to confirm it; for Experience ſhews us, with regard to Metals, that the more ſolid and hard they are, the leſs eaſily are they acted upon by Fire; on the contrary, ſuch as are more porous, and looſely compacted, are quickly heated; which is to be attributed to the Largeneſs of their Pores, which readily admit the Fire. This may be applied to *Gun-powder*; for when it is rammed and compelled into a ſolid Body, the Fire not meeting with Interſtices proper for its immediate Conveyance through the whole Maſs, it is obliged to conſume it by degrees, as long as any of it remains, except it be ſuffocated. Something of this kind may be ſaid of *Powder* that is ſcattered about, and is not gathered together before it is fired; but nevertheleſs with this difference, That in this Caſe the eſſential Strength of the *Gun-powder*, or rather the Fire in it, is not any way diminiſhed, but its Action is ineffectual becauſe of the Diſtance of its Parts; it acts in this Caſe by a Succeſſion of ſmall Action, which might have been conſiderable if collected together into one Act. Thoſe who are but little verſed in *Pyrotechnics*, may have experienced the Truth of what I have here ſaid. The Reaſon I have given why *Powder* when it is corned is more active and powerful than when pulverized, may ſerve in ſome meaſure to clear up that Difficulty; add to which, the Virtue of the *Saltpeter* ſeems to be much more united with the *Sulphur* and the *Charcoal* when in a cloſe Corn, than when meal'd or pulverized. To this let us add, that if you take a very long Piece of Cannon, and fill it up to the Muzzle with well-corned *Powder*, and ſet fire to it at the Muzzle, and not at the Touch-hole as uſual; neither the Fire nor the Powder in this Caſe will do the leaſt Damage to the Piece, inaſmuch as the Fire acts upon the Powder by Progreſſion and not Inſtantaneouſly; beſides the Fire will move downwards, which is the reverſe of its natural Property of acting upwards; or to ſpeak more properly, it not being cloſely confined, and meeting with nothing to obſtruct its perfect Liberty, it burns out at the Muzzle of the Piece.

I ſhall ſilently paſs over the Opinion of ſome who are not very knowing as to this matter, and who imagine the larger any *Gun-powder* is corned, the more lively it will be: Which at firſt does not appear unlikely, and ſeems to agree with what I have been ſaying above: But on the other ſide, the Conſequence of it is wrong; becauſe large Grains are not ſo readily accended, or inflamed, as ſmall ones; and Experience in Fireworks teaches us, That that *Powder* which is in the leaſt Corns, is more vigorous than that whoſe Grains are the largeſt; and the Reaſon is, becauſe the ſmall ones conceive the Fire more readily: Add to

this, that they are more impregnated with *Saltpeter* (the very Life of it all) than the others; and hence it is that they corn it ſmall for the Muſquet and Piſtol, *&c.* and on the contrary take leſs trouble with it, when deſigned for the Uſe of Cannon; for as all great Pieces of Ordinance naturally require a much greater Quantity of *Powder* than the ſmall portable Fire-arms, it is but reaſonable that the *Powder* prepared for the former, ſhould be coarſer than that deſigned for the latter; and indeed it is not only reaſonable but neceſſary likewiſe, to the end that its Interſtices being the larger, the Fire may have the better Convenience of penetrating through the whole Maſs of it, and of accending it at once. Now *Nicolas Tartaglia* in his Book III. Queſt. 10. gives this Reaſon why Muſquet and Piſtol *Powder* ought to be corned: It is (ſays he) to the end, That that Quantity of *Powder*, which is the exact Charge of ſuch Arms, may be more conveniently poured out of the Bandeliers (which are little wooden Meaſures to hold juſt a Load) and that it may run the more freely down the Barrel of the Piece; (although the Bandelier is exactly of the ſame Calibre as the Piece,) which could not eaſily be done if the *Powder* was in a Flower or pulverized, becauſe the ſmall Particles of it cohering together, it would all tumble down at once into the Barrel, and meet with ſome Difficulty in its Deſcent, particularly if the Priming-pan was ſhut cloſe; for in that Caſe it would happen that the Air in the Bottom or lower part of the Barrel having no Opportunity of eſcaping out at the Touch-hole, and the Denſity of the deſcending Flower not admitting of its Excurſion upwards, it would in the end be ſo violently compreſſed as to repel the *Powder* or Flower by its Elaſtic Force, ſo that it would be impoſſible to load ſuch Arms with it, with any manner of Expedition: But this Accident never happens with regard to grained *Powder*, inaſmuch as the Air in the Barrel is at perfect Liberty, by having the Power of eſcaping through its Interſtices: However, great Pieces of Artillery are by no means liable to this Inconvenience; becauſe the *Powder* is always conveyed into them by a Ladle. Here is a way of Reaſoning that has ſome ſhew of Truth on its ſide; though it is far from accounting ſufficiently for the Neceſſity of corning *Gun-powder*; but he is moſt ſtrangely out of the way, when he ſays, that *Cannon Powder* need not be corned at all; which I abſolutely deny, and cannot but think, from his wretched manner of arguing, that He *(Tartaglia)* was ſo far from having ever heard or ſeen the wonderful Effects of *Cannon Powder* upon ſuch perilous Occaſions, as the Wars in his time abounded with, that he never had ſo much as a Sight of any of the *Powder* itſelf.

CHAP. XV.

How to make Gun-powder *of ſeveral Colours.*

THE Blackneſs of *Gun-powder* is entirely owing to the Charcoal; but that Tincture is no neceſſary Adjunct to its Nature, nor does it ſo far contribute to the ſtrengthening of it, but that you may make it of ſeveral Colours with equal Succeſs. For Example; if inſtead of Charcoal you take rotten Wood, or white Paper that has been firſt moiſtened, then put into an hot Oven, and after that pulverized, or any thing elſe that is of a very combuſtible Nature, and very ſuſceptible of Fire (ſuch as I am going to ſpeak of) you will have a *Powder* to the full as effective as the Black Sort. I ſhall then in this Chapter preſent you with ſome Compoſitions, to guide you in making *Powder* of ſeveral Colours.

To make White Powder.

1.

Take of Saltpeter 6 ℔, of Sulphur 1 ℔, of the Pith of Elder well dried one ℔.

2.

Take of Saltpeter 10 ℔, of Sulphur one ℔, of the Rind or Bark of Hemp, after the Hemp is taken out, one ℔.

3.

Take of Saltpeter 6 ℔, of Sulphur one ℔, of Tartar calcined till it is White, then mixed with common Water, and put into an unglazed Pot in which it muſt be boiled till all the Water is evaporated, ℥j.

Red Powder.

1.

Take of Saltpeter 6 ℔, of Sulphur one ℔, of Amber ℔ ſs, and of red Sanders one ℔.

2.

Take of Saltpeter 8 ℔, of Sulphur one ℔, of Paper dried and pulverized, then boiled in Water of Cinnabar, or Braſil Wood, and then dried, one ℔.

Yellow Powder.

Take of Saltpeter 8 ℔, of Sulphur one ℔, of wild or baſtard Saffron, firſt boiled in Brandy, then dryed and pulverized, one ℔.

Green Powder.

Take of Saltpeter 10 ℔, of Sulphur one ℔, of rotten Wood boiled with Verdigreaſe and Brandy, and then well dried and pulverized, 2 ℔.

Blue Powder.

Take of Saltpeter 8 ℔, of Sulphur one ℔, of the Saw-duſt of Linden or Lime Tree *Wood* boiled with Indigo and Brandy, then dried and pulverized, one ℔.

CHAP. XVI.

Of Silent Powder.

SOME People have taken it into their Heads to relate a great many wonderful things of this *Silent Powder*, (which is by ſome very improperly called *Deaf Powder)* and have treated of it in a very prolix Manner: To avoid which, and to prevent my being tireſome to the Reader, I ſhall here only inſert ſome Compoſitions, which I have found to be the moſt excellent and beſt approved of.

1.

Take of common *Gun-powder* 2 ℔, of *Venetian Borax* one ℔; theſe Ingredients being well pulverized and incorporated together, let them be afterwards corned.

2.

Take of common *Gun-powder* 2 ℔, of *Venetian Borax* one ℔, of *Lapis Calaminaris* ℔ ſs, of *Sal Armoniac* ℔ ſs; pulverize and incorporate them well together, and corn them as before.

3.

Take of common *Gun-powder* 6 ℔, Powder of live Moles calcined in a glazed earthen Pot ℔ ſs, of *Venetian Borax* ℔ ſs.

4.

Take of Saltpeter 6 ℔, of Sulphur 8 ℔ and ½, Powder of the inner Rind or Bark of Elder ℔ ſs, of common Salt burnt 2 ℔. Corn all this after the uſual Method.

I ſhall to this add another thing which you may make the Experiment of; for my part I never did, though it is taken out of the *Natural Magic* of the Sieur *de la Porte*, who ſays, that if you add burnt Paper to the Compoſition of *Gun-powder*, or the double of common Hay Seed, well beaten, it will weaken it very much, and prevent it from caſting out ſo much Flame, or making ſo much Noiſe. People of Senſe, and

ſuch

ſuch as are the moſt deeply verſed in this Art, attribute the Noiſe or rather the frightful Clamour of *Gun-powder*, to the violent Concuſſion of the Air, which is impatient of being ſo furiouſly diſturbed, by ſuch a ſtrange and extraordinary Agitation: But of this we ſhall ſpeak more fully in another Place. However in favour of *Silent Powder*, I muſt here quote the Opinion of *Scaliger*, taken from *Lib.* XV. in his *Exer. Exoter. contr. Card. de Subtil. Exer.* XXV. *You are much more out of the way to attribute the* Noiſe *heard upon the Diſcharge of Warlike Machines to* Saltpeter; *for being reduced to a fine Meal it loſes all its little Caverns or Pores.* (You muſt here remember what was ſaid above of the *Detonation* of Saltpeter.) Thunder *is cauſed by the Compoſion of the* Air, *as well with reſpect to its Clap as its Sound; which ſometimes provokes Mirth; ſometimes excites Laughter, and obliges us to ſhut our Noſtrils together. Except you would perſuade us that there is Saltpeter above us: But truly there is none in the Clouds. The* Powder *which you mention to have been invented at* Ferrara, *made no* Noiſe; *becauſe it impelled without Violence.*

From hence it is eaſy to conceive what may be the Cauſe of the Noiſe which *Gun-powder* ſeems to make. For there is nothing further extraordinary in the Compoſition of *Silent Powder*, than that certain Ingredients, a great part of which I have mentioned in this Chapter, have an occult Antipathy to *Saltpeter*, and weaken the common *Powder* when mixed with it. Farthermore, there are ſome Perſons who affirm, that if you beſmear your Hands with the Gall of a Pike, and immediately handle and mix *Gun-powder* about with them, it will have that weakening Effect upon it. But I ſhall leave this, to thoſe who have Faith enough to rely upon the Authors who have made the Experiment. Thus we find by the above Paſſage from *Scaliger* upon this Subject; That *Gun-powder* does not make that ſhocking Detonation, which is heard when any of thoſe Warlike Machines are diſcharged: But that it is owing to the violent Compoſion of the Air, which is diſperſed by the firing of the Piece. We cannot give you a more familiar Inſtance of the Truth of this, than the Wind-Guns which are charged with nothing but Air.

CHAP. XVII.

How to prove the Goodneſs of Gun-powder.

THERE are three different ways of proving *Gun-powder, (viz.)* by the *Sight*, the *Touch*, and by *Fire*. As to the firſt; when you perceive your *Powder* more black than uſual, it is a certain Sign that it is too moiſt; and if you put it upon ſome white Paper, and find that it

blackens it, you may aſſure yourſelf that there is too much Charcoal amongſt it; but if it be of a deep Aſh Colour, inclining a little to the Red, it is a ſure Token that your *Powder* is good.

We try *Gun-powder* by the *Touch* after this manner. Bruiſe ſome Grains or Corns of it with the end of your Finger, and if it readily diſperſes and yields eaſily to the Preſſure of your Finger, you may conclude that there is too much Charcoal in it. If upon ſqueezing, or preſſing it a little ſtrongly, upon a marble or ſmooth wooden Table, you feel Particles that are harder than the reſt, which prick you a little, and that cannot be cruſhed without ſome difficulty, you may infer that the *Sulphur* is not well incorporated with the *Saltpeter*, and that conſequently the *Powder* is not duly prepared.

In ſhort, you may determine with the utmoſt Certainty concerning the Goodneſs or Badneſs of your *Gun-powder* by means of *Fire*, as follows: Lay little Parcels or Heaps of *Gun-powder* upon a clean ſmooth Table, at the diſtance of about 2 or 3 Inches from one another, and ſet fire to one of them; which if it blows up at once, without catching hold of any other Parcels, and makes a little ſort of an acute Noiſe, or produces a white, clear Smoke, riſing with a very ſudden Velocity, and appearing in the Air like a little Circle or Diadem of Smoke; you may depend upon its being perfectly well prepared.

If after the *Powder* is enkindled there remain any black Spots upon the Table, it will be a Sign that there is a great deal of Charcoal in it which has not been ſufficiently burnt; if the Board is as it were greaſy, you may be aſſured that the *Sulphur* and *Saltpeter* have not been ſufficiently purified, or purged of that noxious and viſcous Humour, which is natural to both the one and the other of them. If you find any ſmall Particles which are white, or inclining to Lemon-Colour, it will be a Mark that your *Saltpeter* is not well clarified, and conſequently that it ſtill retains earthy Particles, or common Salt; and moreover, that the *Sulphur* is not pounded or ground fine enough, nor ſufficiently incorporated with the two other Ingredients of the Compoſition.

I ſhall not here ſpeak of ſeveral kinds of Inſtruments, which *Pyrotechnicians* commonly make uſe of to prove the Strength and Virtue of their *Gun-powder:* Having often heard that equal Quantities of one and the ſame ſort of *Powder*, have blown up that which covered them, to ſeveral, and different degrees of height. You may, if you pleaſe, ſee the *Figures* of ſome of them in *Furtenbach*, and others.

CHAP. XVIII.

How to fortifie weakened Powder, *and to reſtore that which is damaged to its firſt Vigour.*

WE call that, damaged, decayed, or weakened *Powder*, which is much degenerated from its firſt Vigour, and the Strength it was indued with at its firſt Preparation. We can attribute its Decay or Imbecility to no other Cauſe, than to the Weakening, or Diminution of the natural Virtue of the *Saltpeter*, or elſe to its actual Separation from the *Sulphur* and *Charcoal*. And this may be owing to two ſeveral Accidents, *(viz.)* to its being either ſuperannuated or too old, or to its being too moiſt. I ſay ſuperannuated; becauſe the *Saltpeter* is greatly affected by the Decay of the *Charcoal*, which is naturally ſubject to Corruption after a certain term of Years. Then as to Moiſture, it is a means of making the beſt part of the *Saltpeter* ſeparate itſelf from the *Sulphur* and *Charcoal*; becauſe as *Saltpeter* is generated from a Water, or from a certain Saline Humour, (juſt as all other Salts are reſpectively produced from theirs) it diſſolves, and returns to its firſt Form, whenever it is any way affected by Humidity: And thus withdrawing itſelf from the two other Ingredients which adhered to it, it either exhales, or ſinks down to the bottom of the Veſſel in which it is kept (if it be made of Clay, hard Stone or Earth) where being ſubſided it remains; and therefore in this Caſe the *Powder* towards the Bottom is heavier than that towards the Top. But if it be kept in Casks, Barrels, or any thing made of Wood, it perſpires through the Pores of that light, or rare Subſtance, and reaſſumes its original Nature; and conſequently leaves the reſt of the Compoſition the lighter by its own Weight, which before conſtituted the greateſt part of the Weight of the whole. But in this Caſe, neither the *Sulphur* nor *Charcoal* will be diminiſhed in Weight; becauſe it is not in their Nature to be diſſolved by any Moiſture: on the contrary, *Charcoal* attracts and imbibes it greedily, and thereby becomes the heavier. Now if you would reſtore *Powder* that begins to decay, or reinſtate that which is perfectly ſpoiled, in its firſt Vigour, you may do it after three ways: and Firſt, Make a Lye with 2 Meaſures of Brandy, one Meaſure of purified *Saltpeter*, one Meaſure of good White-wine Vinegar, ½ a Meaſure of *Salprotic*, ½ a Meaſure of Oil of Sulphur, and ½ a Meaſure of Camphire diſſolved in Brandy; this *Lixivium* being ſtrained through a coarſe ſtrong Searce, ſprinkle or moiſten your damaged *Powder* frequently with it, and dry it in the Sun in wooden Veſſels, then carry it into ſome warm dry place where no Damp can come at it.

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The Second Method of recovering decayed *Gunpowder* is this. First, ſee how much your damaged *Powder* has loſt of its Weight, and upon finding the Difference between its Weight now, and when firſt made, ſupply the Difference with an equal Quantity of fine purified *Saltpeter*; as for Example; let the Weight marked upon the Cask be 1000 lb, and if upon weighing it now, you find that it is but 920; the Difference between the firſt and ſecond Weight will be 80; therefore you muſt add 80 lb of *Saltpeter* to the vitiated *Powder*; then put it all in little Heaps, and pound it, or grind it well after the uſual manner, and corn it as before.

In ſhort, the Third Method of reſtoring weakened *Gun-powder* is as follows, and is the ſimpleſt of them all, and the moſt frequently practiſed by *Pyrotechnicians* and Powder-Makers. Pour out upon coarſe Cloths, or well-jointed Planks, equal Proportions of damaged Powder, and ſuch as has been newly made, and mix them briskly together with your Hands, or Wooden Shovels; then dry it all in the Sun, and putting it up again in your Barrels, keep it in ſome convenient Place till it is wanted.

CHAP. XIX.

Of Buildings *and* Magazines *for the preſerving of* Gunpowder, *together with ſeveral Obſervations on the ſtowing, and keeping it ſecure from Fire, Moiſture, &c. to the end that it may remain entire, and in the full Poſſeſſion of its firſt Vigour.*

AFTER a ſtrict Examination of the Warlike Machines of the Ancients, we muſt allow that they fall ſhort of our *Artillery*, which has been in uſe for theſe laſt Ages: Our *Gun-powder* is now the very Nerves and Life of War; and is the moſt powerful Means that has ever yet been invented, of procuring an happy Iſſue to the Military Enterprizes of Princes, and to decide the Diſputes of the moſt Mighty Monarchs of the Earth. But you will ſay, that our Machines are uſeleſs inactive Bodies, if you deprive them of *Gun-powder*, or if you ſupply them with ſuch as may be ill-prepared, or damaged: Therefore it is of the higheſt Importance, that we be careful in the Preparation and Conſervation of it; and ſo to order Matters, that ſuch a coſtly Thing may not fail of performing the Service and Execution you expected from it. I have ſpoken ſufficiently of the Preparation of it in the xivth Chap. of this Book; but I do not think of cloſing it till I have ſaid ſomething farther upon that Article. In the mean time let us conſider of a proper Situation for our *Repoſitories* or *Magazines* for keeping

keeping *Gun-powder*, together with the proper Form and Conſtruction of ſuch *Buildings*, that they may be exempt from thoſe Accidents which may have the moſt dangerous Effects upon them.

You muſt, in the *firſt* Place, pitch upon a Spot of Ground, which is far from any Marſh or Swamp; which is not in a narrow cloſe Valley, nor in the Neighbourhood of any Spring or Pond; but let it be upon a moderate Height, in an open Country diſincumbered with Woods, and very dry.

Secondly, let it be as far as poſſible from any other *Buildings*; becauſe of ſeveral Inconveniencies that may ariſe from their Proximity; again, let it be in an unfrequented Place, at a good diſtance from any Roads or publick Paths, where People commonly reſort.

Thirdly, let it be well covered and defended from any Danger of the Enemy's Cannon; which may be eaſily provided againſt, by building your *Magazines* in that Quarter of the Town, which ſhall be judged the moſt difficult of Acceſs, and the leaſt ſubject to the Attacks and Storms of the Beſiegers. As for Example, in any Place that is encompaſſed with a Moraſs, or Lake, or a wide rapid River, or in ſhort by the Sea itſelf. In the other Quarter of the Town which is the moſt defenceleſs, and conſequently the moſt in danger of the Enemy's Attacks, you ſhould build very high Houſes and Edifices, whether Publick or Private, in order to cover your *Magazines* from the Beſieger's Batteries, and keep them out of their Sight. For this Reaſon your *Magazines* ſhould be but one or two Stories of a moderate Height, and covered with a low Roof.

In the *Fourth* Place, let them be in the middle of your Curtains, and not in the Baſtions, or near Bulwarks; that you may avoid the danger of Mines, Galleries, and ſecret Saps of the Enemy; or in ſhort at the greateſt diſtance from the Ramparts of the Town, that you may be ſo much the ſafer.

In the *Fifth* Place, theſe *Buildings* ſhall be cloſed up with ſtrong, thick Vaulting within, very firmly cemented, leſt during the Siege any Bombs or Shells, *&c.* falling upon them, ſhould force a Way through, and be attended with pernicious Conſequences to your Powder. The Roof muſt not be covered with Laths, Slate, or Tiling of any ſort, but with Sheet-Lead, or (what is much better) with ſubſtantial Plates of Copper. Again, I would have the Outſide of the Roof be of a Spherical Form, that you need not be obliged to have any Carpenter's Work in it; ſuch as Beams, Timbers, Planking; but that the Tiles, or whatever elſe covers it, may be fixed upon a ſtrong Wall, ſecurely cemented on all Sides with good Mortar.

Sixthly, a Square *Building* will be the moſt convenient of any Form or Figure whatſoever; though I do by no means diſapprove of ſuch as are built Round, or in Form of a *Dome*, as being the moſt capacious of all, and over which the ſtrongeſt Vaults may be built, becauſe of the

Rotundity of their Conſtruction. But if you would build a ſquare one, take care to erect the four Fronts of it, facing the four Quarters of the World.

Seventhly, let the Door be always on the North-Side.

Eighthly, let the Apertures or Windows be as ſmall as poſſible, very narrow, and ſecured with ſtrong Copper or Braſs Bars, ſubſtantial Shutters, and ſtrong Grates of the ſame Metal.

Ninthly, let the Bricks you intend to build your *Powder Magazines* with, be two Years old before you uſe them, and take great care that they be not haſtily dried in the Sun. We are of Opinion, that Bricks which have been burned once, then moiſtened, and burnt over again, are by much the beſt of any, though they are not naturally ſo tenacious of the Mortar; for it has been obſerved, that if they are plaiſtered either withinſide or without, the Lime or Plaiſter does not ſtick upon them long.

Tenthly, and laſtly; Your *Magazine* being built, erected, and covered, or roofed, as it ought to be, you ſhall let it ſtand and dry for the ſpace of two or three Years, before you put any *Powder* into it; and take care not to build it in Winter-time.

You will ſee the *Ichnography* and *Orthographic* Plan of this ſort of *Buildings* in *Fig.* 15 and 16. In the *Ichnographic* Figure, the Letter A ſhows the Room or Apartment, where the *Powder* ought to be kept; B, where the *Saltpeter* and *Sulphur* ought to be reſerved. And C, where the *Charcoal*, and other Materials and Neceſſaries may be laid up, ſuch as *Searces* or *Sieves* of ſeveral ſorts, ſome for ſifting, and others for graining the *Powder*, old Pieces of Linnen, Canvaſs, Boards, or Flooring to dry it upon: And as the Rooms will be ſufficiently extenſive and large, you may in the ſame Place ſtow away empty Casks, or Barrel-Staves, Heading, Hoops, and ſuch like Requiſites. D, is the Winding Stair-caſe, which the *Italians* call the *Lumaca*, by which you go up into the ſecond Story. E, is the Entrance or Portico. F, the Store-keeper's Lodge, or Houſe, who ought to be a Cooper by Trade. G, the Steps. H, the Court, or Yard, which goes round the *Magazine*. I, a little Wall ſix or eight Foot high, that encloſes the Yard and the *Magazine*. K, the empty Spaces, Paſſages, or Alleys, between the *Powder* Barrels, and L the Spaces where the *Powder* muſt be ſtowed. The other Diſtances may be meaſured with a Pair of Compaſſes, as well upon the *Ichnographic* as the *Orthographic* Plan. I ſhall only add, that the *Match* may be conveniently preſerved upon the Floor of the ſecond Story.

In *Fig.* 17. you have the *Ichnography* of a *Powder Magazine*, after the Deſign of *Eugenius Gentillinus* an *Italian*, who has very curiouſly repreſented one of this Nature in Chap. xliv. of his *Artillery*; and is very conveniently contrived againſt all Accidents by Fire. Let us a little explain the Plan which we have here offered. A, is the Inner-wall

of the *Building*, with its Apertures and Lights. B, is the Outward Wall, with Apertures corresponding with the First. C, is the Space between the two Walls. D, E, is the outward Breadth of the Aperture of the Exterior Wall of three Feet. F, G, is the Breadth of it inwards of 1 ½ Foot. I will now direct you how to make the Apertures in the Inner Wall of this *Building*. Let there be drawn from H, to I and K, two Lines each equal to D E, or three Feet: Now if between the Points E I, and D K, you produce the Right Lines E I and D K, they will interſect the Inner-Face of the Interior Wall in the Points L and M; then let there be drawn two Lines equal to F G, or 1 ½ Foot, from the Points L and M, to the Points N and O; then having drawn two Right Lines from H to L and M; if you raiſe a Perpendicular upon N, and another upon O, they will interſect the Lines L, H, and H, M, in the Points P and Q. Thus having drawn D F, E G, I L, O P, P H, H Q, Q N, and M K; you will have the Inward and Outward Breadths of the Lights marked out. I muſt own that this kind of Edifice will be a little dark, on account of the double Wall, and becauſe the Inner Lights L, O, and N M, are exactly covered by the Angles I and K, and conſequently cannot let in much of the Day; beſides that the Angles P and Q, intercept half of the Light which would otherwiſe come to L O, and N M; but on the other hand we muſt conſider, that theſe Buildings ſtand in no need of a great deal of Light, like ſuch as are deſigned for Dwellings; for if there is but juſt ſufficient of it, to direct thoſe who go in and out about the neceſſary Buſineſs of the Place, it is enough. Again, the Wind coming in at D E, ſtriking againſt the Angle H, and being broken and divided towards the Angles I and K, will ruſh briskly in through the Apertures, and refreſh the Air which was in before, and at the ſame time drive away and dry up all that noxious Moiſture to which ſuch cloſe Places are commonly ſubject. As for the neceſſary Precautions of ſecuring your *Magazine* from Accidents by Fire, you will eaſily defend it from that deſtructive Element, if you nicely obſerve what we have already laid down, in the Conſtruction of your Vaults and Roof; for as to the Apertures or Windows, they are ſo well contrived againſt any danger of that kind, that it is impoſſible for any Fire to inſinuate itſelf through them by any Artifice whatſoever.

You may order the Door of your *Magazine* after this manner. The Outward Breadth T U, in the Exterior Wall, and the Inward Breadth R S in the ſame, ſhall be each three Feet. Then from the Angle W, having produced Right Lines to the Points X and Z, and from T and U, to A and Y, you will have the Outward and Inward Breadth of the double Entrance through the Inner Wall. The reſt will be better apprehended from the *Fig.* itſelf, if you attentively conſider it. I ſhall only add, that B b, denote the Spaces where the *Powder* ought to be lodged, and C c the Paſſages between. As to the Orthography of this Edifice, and all the Proportions of its Parts, they may be invented

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at Pleaſure: Nevertheleſs I would have every body to follow the Inſtruction and Method of this Author, whoſe Name I have already mentioned. This is what I had to ſay of the Conſtruction of *Magazines*, and proper Edifices for the lodging and preſerving of *Gun-powder:* Let us now proceed to order what ought to be obſerved, as well in the Preparation, as the Conſervation of it after it is made.

Know then Firſt, that if you would have your *Gun-powder* retain its full Vigour, even though you ſhould lodge it in ſome damp Place, there to remain for ſome time; you need only have *Saltpeter* well pulverized and purified ſeveral times, according to the Method we have preſcribed in the IIId Chapter of this Book.

2. Let each Ingredient have its own Searce for its particular Uſe.

3. Your Ingredients ſhall not be mixed till they have been firſt well dried, ground, and ſearced ſeperately; which done, they ſhall be well ground, incorporated, and ſearced all together over again.

4. In pounding, or grinding them, they ſhall be moiſtened a little with one of the Liquors I have already mentioned, and ſhall be often and carefully ſhaked, or ſtirred, that they may incorporate the better together.

5. Your *Powder* being well and duly prepared, ſhall be put into glazed Earthen Jars, capable of containing each 100 ℔, or thereabouts, with Covers of the ſame, well luted on the Outſide with Glutinous, Bituminous, or any Tenacious Matter, to prevent the Air, or any outward Accident from doing it hurt. I approve very well of Casks or Barrels, made of *Fir* or well-dried *Oak*.

6. Your Veſſels of *Powder* ſhall be placed upon Blocks, or Logs of Wood, of the thickneſs of one or two Feet.

7. Every Year during the hotteſt Months, ſuch as *June*, *July*, and *Auguſt*, you ſhall ſpread your Powder upon Canvaſs, or a Floor of Planks made for that purpoſe, and let it dry well in the Sun and Wind, then ſift it through fine covered Hair Sieves or Searces, and collect the fine Flower or Meal that comes through; but that which remains in Corns ſhall be put up again and covered as before, and carried back again into the *Magazine*.

8. The Cavities and Windows muſt be opened to the Northerly and Eaſterly Winds, that they ruſhing in briskly may purifie the Air confined within. On the contrary, they ſhall be kept cloſe againſt Southerly and Weſterly Winds, as being commonly pernicious to dry Things. For Experience, that Miſtreſs of Knowledge, teaches us, that the Winds blowing from thoſe Quarters being naturally hot and moiſt, they generally beget Taint and Putrefaction in *Flower*. And farthermore, you muſt guard againſt all Winds blowing from the Eaſt towards the South, and from the South towards the Weſt; becauſe all Winds iſſuing from any Point of that Semi-circle, fill the Air with unwholeſome moiſt Vapours, which are of hurtful Efficacy to the Human Body; and we may

reaſon-

reaſonably infer, that as *Saltpeter* is extreamly ſubject to Diſſolution upon the acceſs of any Humidity to it, thoſe Winds muſt have pernicious Effects upon *Gun-powder*.

To conclude; I dare venture to affirm that if the Rules I have now preſcribed for the Preparation and Conſervation of *Gun-powder* are ſtrictly obſerved, you may keep it many Years in full Poſſeſſion of its firſt Vigour, without ſuffering the leaſt Diminution of its Strength. And I flatly deny the Truth of that vulgar Notion, which teaches that *Powder* cannot be kept in Perfection above 2 or 3 Years. There are thoſe who ſay that if you put a little Camphire in each of your Veſſels of *Powder*, it contributes greatly to its Preſervation. This is not unlikely, ſince the odoriferous Smell and extream Dryneſs of Camphire ſtrongly repell all Putrefaction and Corruption which is generated by damp Vapours. It has been frequently obſerved, that Compoſitions have been taken out of Grenado's and Shells of long ſtanding, which have been in perfect good State, and ſmelt much of Camphire. From whence we may conclude, that a Mixture of Camphire with *Gun-powder* contributes pretty much to its Preſervation. But I ſhall ſpeak more largely of this in another Place.

CHAP. XX.

Of the Properties and particular Offices of each Ingredient concerned in the Compoſition and Preparation of Gun-powder.

WE muſt not think that *Gun-powder* was caſually, or accidentally diſcovered; but on the contrary, that it was invented and perfected, by ſound ſpeculative Reaſonings, drawn from the Principles of *Natural Philoſophy*; inaſmuch as no Man to this Day could ever yet (though many have endeavoured at it) contrive an Aſſemblage of three ſuch Ingredients as theſe, which being united and incorporated together, would naturally produce ſo vigorous, ſo frightful, and ſo ſudden a Fire, and at the ſame time ſo inextinguiſhable, and univerſally abſorbant of their own Subſtance. Now as it is no Novelty in our Age, for Men to add to, and enlarge upon preceding Inventions, and ſince (as the *Metaphyſicians* have it) all Things that have a Beginning paſs from Imperfection to Perfection; I beg leave to make ſome Obſervations upon *Gun-powder* (the Inventor of it having left nothing in writing behind him concerning it) which though they are indeed ſpeculative, are nevertheleſs grounded upon Experience of the Nature, Effects, and particular Properties of all the Ingredients which enter into the Compoſition of

Fig. 11.

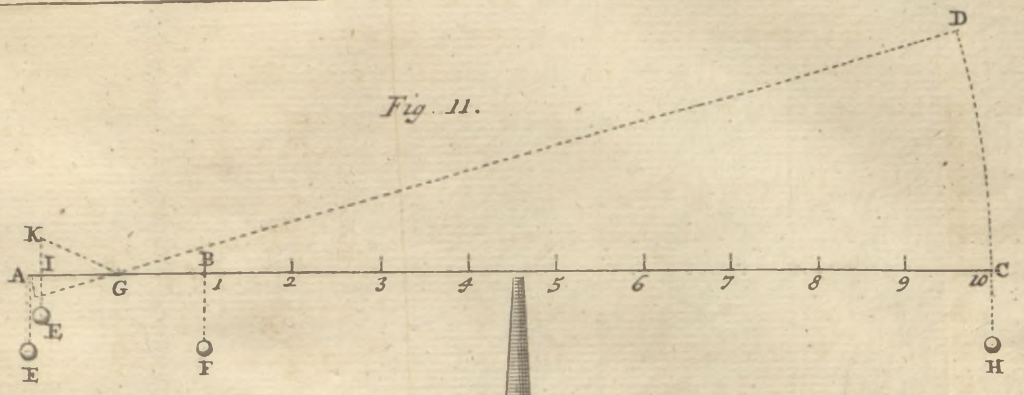


Fig. 12.

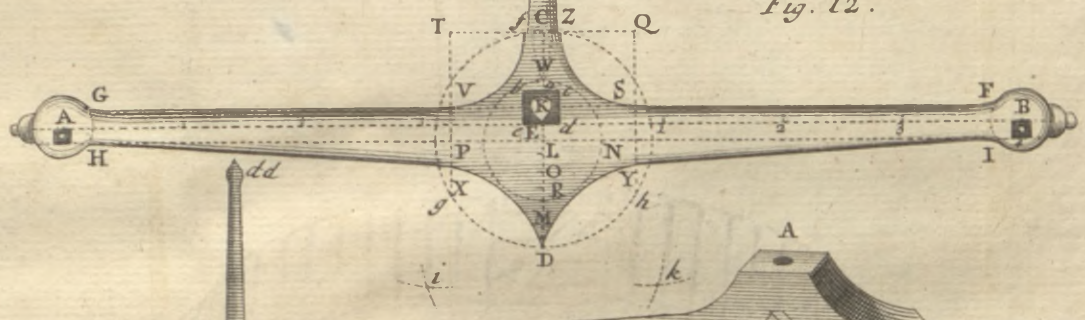


Fig. 13.

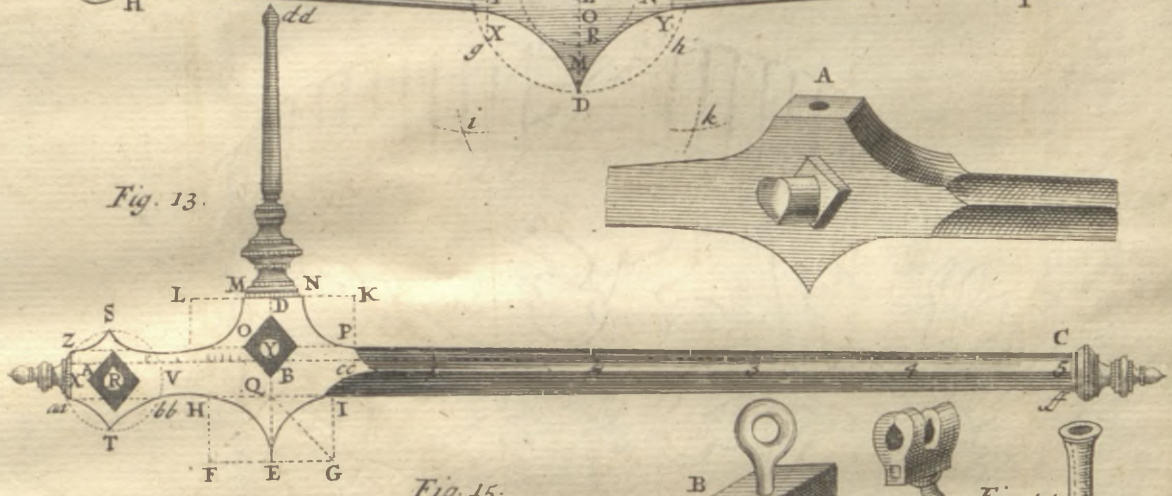
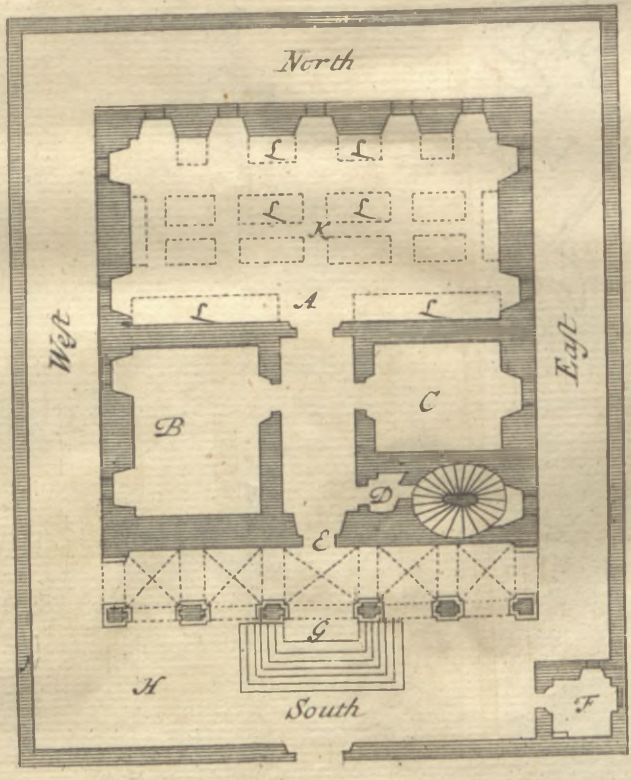


Fig. 15.



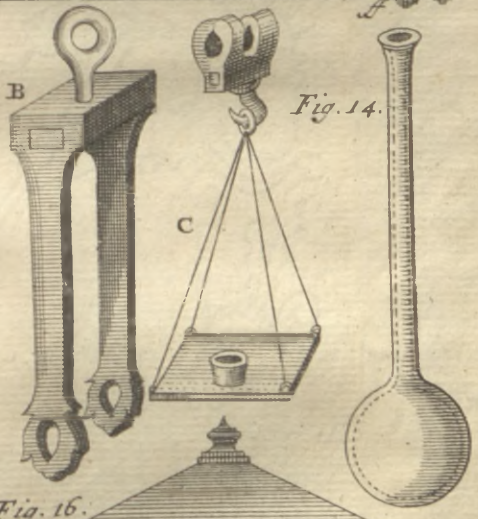
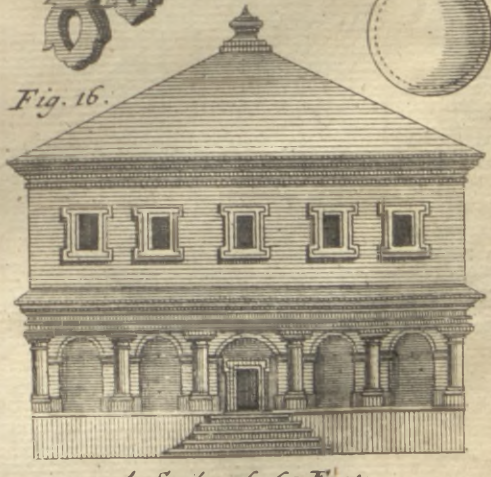


Fig. 14.

Fig. 16.



A Scale of 60 Feet.

5 10 20 30 40 50 60

C

P. F. sculp.

it, as well when ſeparated from one another, as when united into one Body. For I cannot but think that a few Words upon this Subject, will be ſo far uſeful, if well digeſted, as to prevent the frequent Errors committed in *Pyrotechnics*; a Correction of which is not only very dangerous, but likewiſe very expenſive.

You muſt know then, *Firſt*, that it is not without Reaſon, that *Gun-powder* is compoſed of theſe three Ingredients, namely, *Saltpeter*, *Sulphur*, and *Charcoal*; but to the End that one of them might remedy and ſupply the Defects of another, or of the other two. This may eaſily be comprehended by the Nature and Effects of *Sulphur*, which is of itſelf the very Quinteſſence of Fire, or rather a pure Flame, and is therefore more proper to accend the *Saltpeter* than any other Fire whatſoever: But as *Saltpeter* being once inflamed by it, is inſtantly rarified into a *Flatulent* or Windy *Expanſion*, it would by its Violence infallibly extinguiſh the Flame which had been conceived by the *Sulphur*, and deprive itſelf of that Heat which the *Sulphur* would have communicated to it: And therefore if a Compoſition was made of *Saltpeter* and *Sulphur* only, well pulverized and incorporated together, it would indeed moſt readily conceive the Fire, and break out into a Flame, but it would inſtantly go out again, for the Reaſon above given: That is, the Fire would not be ſufficiently laſting to conſume the whole of it, but would only deſtroy a Part, without affecting the reſt. Upon this Account it was thought proper, that *Charcoal* well burn'd, dried, and pulverized, ſhould be added to them in a certain Proportion, as an excellent Thing to ſupply this Defect; for *Charcoal* is very ſuſceptible of Fire, and is inſtantly conſumed with a Flameleſs Heat; whence it happens that the more it is agitated by Wind or Air, the fiercer it burns till it is entirely reduced to Aſhes. From the ſeveral Properties of theſe Ingredients we may eaſily perceive, that any Body compounded of them, as *Gun-powder* is, muſt not only be very ſuſceptive, but alſo retentive of Fire, even to the Combuſtion of its very laſt Atom; for the *Sulphur* immediately catches Fire whenever applied to it, and inſtantly accends the *Saltpeter*, and ſets Fire to the *Charcoal*, which (as I have already ſaid) burns without any Flame, and glows with the greater Rage, the more it is agitated by the Wind or Air: The Conſequence of which is, that the *Sulphur* being unable to withſtand Fire, but on the contrary being inſtantly inflamed by it, the intenſe Heat of the *Charcoal* prevents the Flame of the *Sulphur* from being extinguiſhed by the windy *Expanſion* of the *Saltpeter*; therefore it continually keeps up the Flame of the *Sulphur*, and the Flame of the *Sulphur* inceſſantly acting upon the *Saltpeter*, they muſt, when they are all three duly incorporated together, produce ſuch a Fire as is not to be extinguiſhed, till the whole Subſtance of them is conſumed by it, and to all Appearance annihilated. Great Care, however, is to be taken, that neither of the three be affected by any improper Accident, ſuch as Moiſture, or a diſproportionate

Quantity of its Matter. Now from what we have been ſaying, we may conclude that the true Office and principal Buſineſs of *Sulphur*, as it is an Ingredient in *Gun-powder*, is firſt to conceive the Fire, and then communicate it to the two others. That the Buſineſs of *Charcoal* is to retain the Fire when once introduced, by preſerving the Flame of the *Sulphur*, and preventing it from being deſtroyed by the *Flatulent Expanſion* of the *Saltpeter*. And in ſhort, that it is the great Buſineſs of *Saltpeter* to produce a moſt violent and reſiſtleſs *Expanſion*, and in this conſiſts all the moving, expulſive, and active Force of *Gun-powder*; conſequently *Saltpeter* is the principal Cauſe of the terrible Effects of it, and it muſt now plainly appear that the other two Ingredients are only joined with it, to put it in Action. As a Proof of this; if any one was to make a *Powder* of *Sulphur* and *Charcoal* only, and was to charge any large Piece of Cannon with it; it would be found to be ſo far from being able to drive out a Bullet, that it would not even diſlodge a Straw: And the Reaſon of this Imbecility is ſelf-evident, from what we have already ſaid, having demonſtrated that the expulſive Quality of *Gun-powder* is entirely owing to the *Expanſion* of the *Saltpeter*. Upon the whole, it would be a much eaſier matter to contrive a *Powder* without *Sulphur* or *Charcoal*, than without *Saltpeter:* Or it would be leſs difficult to find two Things, the one to perform the Office of *Sulphur*, and the other to act in the ſame manner as *Charcoal*, than to meet with any Subſtance which would have ſuch a violent Effect and ſuch occult Qualities as *Saltpeter*.

CHAP. XXI.

Of Aurum Fulminans *or* Saffron *of* Gold----- *taken from the* Royal Chymiſtry *of* Oſvaldus Crollius.

TAKE ½ ℔ *of common* Aqua-fortis, *diſſolve in it an Ounce of* Sal Armoniac, *or as much as a little heat can diſſolve of it; thus you will have your* Aqua Regis *prepared, in which you may diſſolve as much Gold as you pleaſe. Pour off this* Solution *into another Glaſs, and drop into it Drop by Drop only (becauſe of the great Danger and Noiſe of its Effervescence) of the beſt Oil of Tartar* per Deliquium, *or for want of that take Salt of Tartar diſſolved in common Water; (for you muſt have a good quantity of this Oil of Tartar ready) upon which the Gold will precipitate to the bottom of the Glaſs: And as ſoon as you ſhall perceive that all the* Calx *of the diſſolved Gold is ſettled in the bottom of the Glaſs, (which you will eaſily know by the Colour of the* Aqua Regis, *which ought to be white; for if it is yellow, it will be a Sign that the Gold is not quite precipitated; therefore*

in

in such a Case you must drop a little more of the Oil of Tartar into it; and be thou wise at my Expence :) I say; when all the Gold is fallen, you shall a few Hours afterwards pour off the Liquor that is upon it, in some warm place, and having softened the Calx *three or four times with warm Water, let it be gradually dried, by a slow Fire in* Balneo Mariæ; *or to do it with the more safety put it into a Glass Bason, and let it dry of itself without coming near the Fire, then gather it up with a wooden* Spatula, *(for you must avoid using any thing made of Iron,) and put it up in an earthen Pot against you want it. Observe here, that it is very dangerous to dry it after any other Method than what I have here prescribed; for it is very apt to take Fire upon the least occasion, and breaks out into a kind of purple Smoke, and a frightful Noise not unlike that of* Gun-powder, *and is so universally absorbed by the Flame that there is not the least Atom of it left after its Combustion: And what is very extraordinary; if you mix a little well pulverized* Sulphur *with it, and burn it in a Crucible, you will have a kind of* Calx *very subtile, and of a brown Colour, which is entirely divested of this* Fulminating Quality. *But that which is the most wonderful of all is, that a Scruple of this Volatile Gold, is incomparably stronger, and acts with infinitely more Violence than half a Pound of* Gun-powder. *If but a Grain or two of it be put upon the point of a Knife, and heated by the Flame of a Candle, it makes as much Noise as a Musquet, but it is a Noise which assaults the Ear with so much Violence, that the extreme Acuteness of it deafens those who are pretty near to it. The greatest difference that we find between this* Powder *and* Gun-powder *is, that the Effects of the one are diametrically opposite to the Operations of the other; inasmuch as this Thundering* Powder *acts by* Descent, *on the contrary the other by* Ascent; *for if* (for Example) *you put some Scruples of it upon an Iron Plate of moderate thickness, and set fire to it, it will infallibly pierce downwards through and through the Plate; and we may believe that the* Sal Armoniac *is the Cause of this odd Effect. For just as* Saltpeter *and* Sulphur *are violent Enemies to one another, as may be observed in the accending of* Gun-powder, *so is it with the* Sal Armoniac *and* Oil *of* Tartar, *whose Qualities are entirely incompatible with each other; therefore when the* Sal Armoniac *comes to be incorporated with the* Oil *of* Tartar, *they by the Contest of their Antipathetical Qualities, force the Gold down to the bottom, which had before been dissolved in the* Aqua Regis: *And thus the* Oil *of* Tartar *precipitates the perfectly pure Spirit of Nitre, which in this Conflict unites itself with the* Solar Sulphur *its Adversary; and because this* Sulphur *of the Sun is infinitely more refined, pure, and combustible than the common Sort, it produces an Effect proportionate to its superior Virtue; and this pure* Nitre *and* Sulphur *of the Sun act upon each other just as the common* Sulphur *and* Saltpeter *do. It is of this that* Quercetanus *and* Sennertus *speak in a certain passage, (according to* Joh. Jonstonus Adm. Nat. Clas. IV. Cap. xxvi.) *when they say, that the Effects produced by the Spirit of* Nitre *and* Solar Sulphur *proceed from the Contrariety and extreme Antipathy between them.*

them. For as the Oil *or* Salt *of* Tartar *is poured into the* Solution *of the Gold, the* Salt *of* Tartar *unites and incorporates with the common Salt, or the Allum, and the* Sal Armoniac, *which conſequently forces the Gold downwards; and if by chance any of theſe Salts remain with the Gold, it muſt be well waſhed with hot Water. Thus nothing remains with the Gold but the Spirit of Nitre which is entirely incorporated with it; ſo that when it comes to be heated, it adheres immediately to the* Sulphur *of the* Gold, *powerfully oppoſes it, and rallying all its Force, is lighted and goes off with a frightful Clap.*

CHAP. XXII.

Of the Preparation of Flowers *of* Benjamin.

TAKE a certain quantity of *Benjamin*, and put it into a Glaſs Alembic or ſubliming Pot, covered with a Blind Head: At the ſame time you muſt have a ſhallow earthen Veſſel with a wide Mouth, which you muſt ſet upon a Tripod, or to be the ſafer upon a little diſtilling Furnace; you ſhall put your Alembic or Subliming Pot into this, and encompaſs it well with Aſhes, or elſe with well-waſhed Sand, to the height of the Matter contained in your Subliming Veſſel. Then light a gentle Fire under the Earthen Pot, for fear your Alembic ſhould be too ſuddenly heated, the conſequence of which would be, that the *Flowers* you extract would be of a Lemon-colour or yellowiſh Caſt, inſtead of being (as they ought to be) as white as Snow. As ſoon as you perceive the *Benjamin* to emit any Fume, continue your Fire in the ſame degree of Heat for a Quarter of an Hour; and as ſoon as you ſee that the *Flowers* are ſublimed to the inner Surface of the Head, take it off quickly, and put another cold one on in its place, and let that which you took off cool at leiſure upon a Sheet of white Paper; then with a Feather gently ſcrape off the fine *Flowers* which you will ſee ſticking to the Head, and gather them carefully together. Thus you may do with the ſecond and third Head, and ſo on with ſeveral others till the *Benjamin* will ſublime no longer.

Another Method to the ſame Purpoſe.

Put a certain quantity of *Benjamin* into a glazed earthen Pot, and ſet it upon hot Aſhes, and as ſoon as you ſee the *Benjamin* begin to fume, cover your Pot with a great Paper Head in form of a Cone, (as the Chymiſts have it, a *Cornet*) which ſhall be a very little wider than the Orifice of the Pot: Let it ſtay on for about a Quarter of an Hour. Then take it off, and ſcrape the *Flowers* from it; taking care to put on another

ther freſh Head immediately, which ſhall remain on as long as the firſt, then taking it off, do as before, ſtill continuing to put on one Head after another as long as the *Benjamin* will ſublime or exalt.

CHAP. XXIII.

How to prepare Camphire.

TAKE of Gum of Juniper (which is ſometimes called *Sandarac*, white Varniſh, or Maſtich) very finely pulverized 2 ℔, and as much White-wine Vinegar as will be ſufficient to cover the Gum in a Phial: Bury it deep in Horſe-dung for the ſpace of 20 Days, then take it up and put it in another Glaſs Veſſel with a wide Mouth, and expoſe it to the Sun for the ſpace of a whole Month. Thus you will have your *Camphire* concreted in the Form and near Reſemblance of a Cruſt of Bread. We have already hinted at the natural Properties of *Camphire*, but nevertheleſs as we make great uſe of it in our Compoſitions, I ſhall here treat of the Nature of it at large from the Teſtimony of good Authors. Firſt, *Scaliger Exercit.* CIV. 1. ſpeaks of it thus. *Sed ad rem arboris, lachryma eſt Capura, ne bitumen credas, ſicuti ſuccinum bitumen credidiſti*, &c. *You muſt not imagine* Camphire *to be a Bitumen as you did with regard to Amber, but a Gum and the Diſtillation of a Tree, which falling, is tranſported by the Tides and Currents of the Sea to Shores where it is buried in the Sand, in which Situation it is found all along the Coaſt from* Memel *to* Gedan. *This will not appear ſtrange to ſuch as have been in thoſe Parts, or that have ever ſeen the Weſt-ſide of* Holland, *where great Heaps of Sand are accumulated by the Sea.* Camphire, *therefore, can be no farther deemed a Foſſil than as it is dug up from the Sand. Thoſe are ſtrangely out of the way, who conclude it to be a Bitumen from the wretched Argument of its Combuſtible Nature; for we ſee the ſame Property in Roſin, Oil and Frankincenſe, and ſuch like Things.* Again, he ſays a little farther, Camphoram vero cum ſapientum maxima pars, frigidiſſimam ſtatuat, *Avenrois* in quinto aliam agnoſcit, *&c.* The *Engliſh* of which is: *That the greateſt part of the Learned have always taken* Camphire *to be cold in the very utmoſt Degree: But* Averroës *ſpeaks of a ſort which was only cold in the fifth Degree. For (ſays he) the* Indian Camphire, *which in* Arabick *is called* Coforalgent, *heats and dries in the ſecond Degree; therefore there muſt have been different kinds of it, or elſe the Book muſt be erroneous, or the Opinion miſtaken. At length it was queſtioned whether it was cold, which the Innovators denied. For truly it is very Combuſtible, will even burn in Water, and is very Odoriferous: But this laſt Property is derived from its ſubtile Particles, by the power of which alſo it burns. It contains as much Water as is neceſſary for it to preſerve its Frigidity under that Form: but it burns becauſe of its Oili-*

neſs. Sure Folly is either the Mother or Daughter of Ignorance; for who would affirm that Things which are by Nature the hotteſt, are alſo the moſt ſuſceptible of Fire, ſince Fire has not always the moſt powerful Effect upon its Likeneſs; (I mean its Likeneſs with regard to Heat) but on the contrary upon ſuch Subſtances, the porous Contexture of whoſe Parts the moſt readily permit it to inſinuate itſelf. I find in the Commentaries of the Indian *Obſervables, that the Tree is of the largeſt ſort, ſpreading its Branches, and creating a Shade a great way round it. The Wood of it is very light and porous, and the* † Aboali *add, that it is white. The Goodneſs of* Camphire *depends upon the manner of its Extraction from the* Matrix, *or Place where it is formed, that is, whether it be gathered before it is expelled by Nature, or afterwards; for ſome of it is taken out of Veins, where it is generated like a Cruſt; ſometimes it burſts the Rind or Bark and forces a Paſſage out, where it is concreted, and looks at firſt like Roſin, and is afterwards blanched by the Sun, or by Art. This ſort is better than the firſt; but that is beſt of all, which is whitened by the Sun: It alſo may be done with Fire; which Operation was firſt performed in Imitation of Nature, by* Riach: *a King of that Place; from whence it has the Name of* Riachina. *That which is gradually diſtilled, is by much the pureſt and beſt, and is the moſt pellucid: but that which remains incloſed in the Subſtance of the Tree, is more groſs, and of a dark Colour. There are beſides theſe, two ſorts of a baſer kind. The one rough, coarſe, and gummy; the other of a deep dusky Colour. It is to be adulterated or counterfeited, with Suet, Maſtick and Brandy.* But, ſays he, *You may thus diſcover the Fraud; put ſome of it into the Heart of a Loaf, and ſet the Loaf in an hot Oven; if it liquifies, it will be good, and of the right ſort; but if it dries up, you may take it for granted, that it is ſpurious and adulterated: They ſay the right ſort eaſily evaporates. When you have that which is good, you may keep it in Marble Boxes, with Linſeed, Flea-wort Seed, or Millet Seed amongſt it.* Jonſtonus Admir. Nat. Claſ. iv. Cap. ix. Scribunt Mauri Camphoram lachrymam eſſe arboris, &c. *The* Moors *write, that* Camphire *is the Tear of a Tree, whoſe Branches ſpread abroad to that degree, as to be able to ſhelter an hundred Men under its Shade. They add, that the Wood of it is white and ſoft, and that it contains the* Camphire *in a light ſpongey Pith. But this is uncertain; it is more probable that it is got from a kind of* Bitumen *after this manner. The* Indian Bitumen, *which ſprings forth of the natural* Camphire *being put over a Fire in ſome covered Veſſel, the finer Particles of it are ſublimed by the Violence of the Heat, and adhere like fine whitiſh Flowers to the Cover of the Veſſel; and which being collected give it that Form in which we ſee it. There are Merchants who affirm, that the natural ſort is to be ſold in* India. *It is ſo very fond of Fire, that having once conceived it, it burns as long as any of its Subſtance remains. It emits a bright, odoriferous Flame, which being carried up and ſuſpended in the Air, it inſenſibly vaniſhes, which is owing to the Subtility of its Parts.*

To

† A People of *India* ſo called; but according to *Pliny*, *Abali*.

To this I ſhall add, that it will be very eaſy to pulverize *Camphire* for the Uſe of *Artificial Fireworks*, if it be ground and pounded gently with *Sulphur* in a Mortar. The *Oil* of *Camphire*, which anſwers the ſame End, is made by adding a little *Oil* of *Sweet Almonds*, and grinding them together in a braſs Mortar, with a Peſtle of the ſame Metal, till all of it be turned into an *Oil* of a greeniſh Colour. Or if your *Camphire* be good, and pure, you may ſtop it cloſe up in a Glaſs Phial, and put it into an hot Oven, where let it remain till you judge it to be thoroughly diſſolved: Your *Camphire* will then yield you a fine, clear *Oil*, which will burn with admirable Sprightlineſs.

CHAP. XXIV.

Of Water *of* Sal Armoniac.

TAKE of *Sal Armoniac* ℥iij, of *Saltpeter* ℥j, pulverize them very fine, and mix them well together; then put them into an Alembic, and after having poured ſome of the beſt and ſtrongeſt Vinegar you can get, upon them, diſtil them over a ſlow Fire.

CHAP. XXV.

Of a certain Artificial Water, *which burns upon the Palm of the Hand without doing any Hurt.*

TAKE of the *Oils* of *Naphta* or *Petrol*, and *Turpentine*, of *Quick Lime*, *Mutton Suet*, and *Hog's-Lard*, an equal Quantity of each, then beat them together till they are well incorporated; which done, diſtil them over hot Aſhes or burning Coals.

CHAP. XXVI.

How to prepare the common Sort of Match.

LET there be firſt twiſted ſome Rope, of half an Inch Diameter, made of the ſecond Combings of Flax or Hemp, free from any of the Stalks. Then take of Aſhes of *Oak*, *Aſh*, *Elm*, or *Maple*, three Parts, of *Quick Lime* one Part, and make a *Lye* of it as uſual; to this you ſhall add one Part of *Saltpeter*; and of the Juice of Horſe

or

or Ox-Dung well filtrated, and gently expreſſed through a Woollen Cloth, or Sieve, 2 Parts. Theſe Ingredients being well incorporated, ſhall be poured upon the Rope in a Braſs Cauldron, well fixed upon a Furnace; the Fire ſhall be at firſt lighted under it by ſlow Degrees, till it is arrived to the higheſt Pitch. Thus it muſt boil continually for the Space of two or three Days, being conſtantly fed with freſh Supplies of your *Lye* as faſt as it is wanted, leſt either your *Match* or *Cauldron* ſhould burn. In ſhort, your *Match* having undergone this Ebullition, you ſhall take it out of the Liquor, and wring it well, continually wiping off the Liquid which ſqueezes out of it with a Linnen Rag; and then hang it upon long Poles to dry in the Sun; after which it may be laid up in ſome convenient Place till wanted.

CHAP. XXVII.

How to prepare Match *or* Fire-Rope, *which will neither ſmoke nor yield any ungrateful Scent.*

TAKE certain Meaſures of fine Red or Carbuncular Sand, well waſhed and dried, a Layer of which you muſt put into an unglazed Earthen Pot, and upon that, a Layer of common *Match*; which you muſt coil in a Spiral Line, in ſuch a manner, that there be the Diſtance of half an Inch between each Revolution of it. Over this *Stratum* of Rope, put another deep one of Sand, and upon that another *Stratum* of *Match* or *Rope* as before, and ſo on alternately Layer upon Layer, till you have filled the Pot, which muſt be covered with a Lid of the ſame, and well luted with Clay, that no Air may have Acceſs to it. The whole being thus ordered, you ſhall encompaſs it with lighted Coals, in which Poſture it muſt remain for ſome time: You ſhall then ſet it to cool, and being quite cold, take out the Sand and *Match*. You may alſo proceed in this manner in the Preparation of common Sponges, except that they muſt be firſt cut into ſmall longiſh Pieces. If you take lighted Pieces of the above-mentioned *Match*, and bury them in the Aſhes of *Juniper* Wood, they will burn ſome time without any ill Smell, and the outward Air will not conſume them ſo faſt as it does common *Match*; therefore you may hide it where you will, without fearing it will be diſcovered either by its Smoke or Smell.

CHAP. XXVIII.

The Manner of preparing Pyrotechnic Sponges.

TAKE of the greateſt and oldeſt *Muſhrooms*, or *Toad-ſtools*, that grow at the Roots of *Aſh*, *Oak*, *Fir*, *Birch*, and other ſorts of Trees; ſtring them, and hang them up in a Chimney, where being macerated, take them and cut them in Pieces, and beat them vehemently for ſome time with a Wooden Mallet. This done; boil them over a ſlow Fire in a ſtrong *Lye*, with a good Quantity of *Saltpeter* in it, till all the Moiſture is evaporated. Then put them upon ſmooth Boards, and ſet them to dry in an Oven of moderate Heat, after which you muſt beat them with a Wooden Mallet as before, till they are perfectly ſupple and ſoft. Thus prepared you ſhall keep them in a proper Place till wanted.

CHAP. XXIX.

How to prepare ſeveral ſorts of Quick Match *for* Artificial Fireworks.

YOU ſhall make *Match* of the Tow of *Flax*, *Hemp*, or *Cotton*, of two or three Strands, but moderately twiſted, and put them in a new glazed Earthen Pot. Pour upon them of good *White-wine Vinegar* 4 Parts, of *Urine* 2 Parts, of *Brandy* 1 Part, of purified *Saltpeter* 1 Part, and of pulverized or meal'd *Gun-powder* 1 Part. Boil all theſe Ingredients together over a quick Fire, till all the Moiſture is evaporated. Then ſtrow *Flower* or *Meal* of the beſt *Gun-powder* you have upon a ſmooth large Plank, and rowl your *Match* in it; after which let it dry in the Sun or the Shade, no matter which. That which is prepared after this manner conſumes very faſt; but if you would have it to burn ſlower, you may make your *Lye* or Liquor weaker than we have above preſcribed; and therefore you may boil it in *Vinegar* and *Saltpeter* only, then powder it over with *Flower* or *Meal* of *Gun-powder*, and let it dry as we ſaid before.

There is another kind of *Pyrotechnic Quick Match*, which is not twiſted at all, but is only boiled juſt as it is, in the above-mention'd Compoſition, or elſe ſteeped in good *Brandy* for ſome Hours, and then powdered over with *Flower* or Meal of *Gun-powder* as before, and dried. There are thoſe

who add a little *Gum Arabick* or *Tragacant* to the *Brandy*, particularly when they would have it ſtick faſt to any thing.

Francis Joachim Prechtel, in the ſecond Part of his *Pyrotechnics* Chap. II. gives an Account of a kind of *Quick Match* which is very ſlow in taking Fire, and in burning. He thus orders the Preparation of it. Take of *Maſtich* 2 Parts, of *Colophonia* or Fine *Roſin* 1 Part, of *Wax* 1 Part, of *Saltpeter* 2 Parts, of *Charcoal* ¼ Part. Burn them to that degree, that they may be eaſily pulverized, and grind each of them ſeparately into a very fine *Meal* or *Flower*. Then mixing them well together, fuſe or diſſolve them upon the Fire. This done, take your *Match* made either of *Flax* or *Hemp*, of a pretty tolerable thickneſs, and dip it into this Compoſition, and repeat your dipping till it has acquired the Size of an ordinary Candle. When you would uſe any of this, light it thoroughly at firſt, then blow out the Flame, that there may remain nothing but the burning Coal.

CHAP. XXX.

How to prepare Lutum Sapientiæ *or* Lute.

TAKE what Quantity of *Loam* you want, and dry it, beat it, and ſearce it well, and with it mix ſome Shreds of Raw Silk, or the Sheerings of Woollen-Cloth: Upon theſe you muſt put either Horſe or Aſs-Dung, or Fileings of Iron; knead them well together with a ſufficient Quantity of Whites of Eggs; and with this *Paſte* or *Lute* you ſhall ſtop up the Glaſs or Earthen Veſſels you intend to put upon the Fire. You muſt uſe it whilſt it is freſh and moiſt; for after it is dry it will be of no Uſe to you.

Or elſe take of White Chalk or Plaſter 4 Parts, of common Aſhes ½, of Horſe or Aſs-Dung dried 1 Part, together with a little of the Fileings of Iron, and Shreds of Raw Silk. Beat them firſt with a Stick, then with a Shovel, or Wooden Pounder: After which, being well kneaded, they ſhall be put upon ſome firm Plank, or fixed Stone, and beaten over again, till they are ſufficiently mixed and incorporated.

CHAP. XXXI.

Some Excellent and Approved Medicines and Antidotes againſt Burns *by* Gun-powder, Sulphur, *Hot* Iron, *Melted* Lead, *&c.*

From my own Experience.

1.

BOIL ſome freſh *Hog's-lard* or *Fat* in common Water, over a gentle Fire, and then expoſe it to the Air for 3 or 4 Nights. Put it afterwards into an Earthen Pot, and melt it over a ſlow Fire, and ſtrain it through a fine Linnen Cloth, over cold Water; then waſh it in clear Water till it is perfectly white, and put it into a Gally-Pot againſt you want it. This is for anointing the Part that is burnt as ſoon as poſſible. The Effect of it is ſudden and admirable.

2.

Take of *Plantain Water*, and *Oil* of *Italian Nuts*, a *quantum ſufficit* of each.

3.

Take of Water of *Mallows*, of *Roſes*, of *Allum Plume*, a *quantum ſufficit*, and mix them well together, with the White of an Egg.

4.

Make a *Lixivium* or *Lye* of pure Quick Lime and common Water; and add to it a little of the *Oils* of *Hempſeed*, *Olives* and *Linſeed*, together with ſome Whites of Eggs; mix them well together, and anoint the Part which is burnt with this Compoſition. All theſe Ointments cure Burns without Pain, or leaving any Scar behind; as I my ſelf have often experienced.

Receipts *taken from ſeveral others.*

Take *Oil* of *Olives* 1 Part, of *Oil* of *Sweet Almonds* 1 Part, Juice of *Onions* 2 Parts, of *Liquid Varniſh* 1 Part; rub the Part affected with this Compoſition.

If the Part happens to be bliſtered, or ulcerated, the following Ointment is very excellent in ſuch a Caſe.

Boil a good quantity of the inner *Bark* of *Elder*, in *Oil* of *Olives*, and ſtrain it through a Linnen Cloth; then add to it 2 Parts of *Ceruſe*, of burnt *Lead*, of *Golden Litharge* 1 Part each; put them all together in a Leaden Mortar, and mix and pound them till they are reduced to a Liniment. You muſt take care not to break the Bliſters the firſt or ſe-

cond Day; but afterwards you may do it; for theſe Accidents are ſometimes cured by Perſpiration only; according to *Leonardus Bottalus de Vulneribus Sclopetorum*, Cap. xxi.

2.

Melt *Lard* into ℥ ij of *Water* of *Morell*, or *Garden Night-ſhade*, and ℥ j of *Oil* of *Saturn*. Mix them well together. This is a ſovereign Remedy.

Or take Mucilage of *Henbane Roots*, and Flowers of *Red Poppies*, of each ℥ j, of *Saltpeter* ℥ j. Mix them together with *Oil* of *Camphire*, and make a Liniment of them according to Art.

Or take of the Juice of *Onions* roaſted under hot Aſhes ℥ ij, of *Oil* of *Walnuts* ℥ j. Mix them well together.

Or (if you will) take of the Leaves of *Black Ivy* 2 Handfuls, well pounded with *Plantain Water*; *Oil* of *Olives* 1 ℔. Boil them all with ℥ iij of good *White Wine*, till all the Wine is evaporated: When the Coction is over, put as much *Wax* amongſt it, as is neceſſary, to give it the Form and Conſiſtence of a Liniment.

Again; take old *Lard*, melted by a Flame, and received in ℥ ij of the Juice of *Beet Root* and *Rue*, of the Cream of *Milk* ℥ j, of the Mucilage of *Quince Seed*, and *Gum Tragacant*, or *Dragant*, of each ℥ ſs. Mix them well, and make a Liniment of them. *Joſephus Quercetanus*, *in Libro Sclopetario*, tells us this is a good Remedy.

CHAP. XXXII.

Of a certain new Invention for meaſuring Gun-powder, Saltpeter, Sulphur *and* Charcoal; *together with a* Searce, *and ſeveral other* Things *requiſite in the Preparation of thoſe Ingredients.*

YOU will ſee the Form of this new-invented Inſtrument in *Figure* 18, the Conſtruction of which is very ſimple, and you may eaſily order it after this manner. Make a Cylinder with a Copper Plate, and ſolder it well. Though its Breadth A B, and its Height A C, or B D, are arbitrary, it will nevertheleſs be better if you have a certain determined Dimenſion. In our Example, let us ſuppoſe a Cylinder that holds 4 ℔ of ordinary *Gun-powder*, upon which Account the Side I H of the ſquare Inſtrument or Scale (which is juſt as long as the Cylinder is high) is divided into 4 equal Parts, each Diviſion anſwering to 1 ℔; we then ſubdivide each of them into 2 equal Parts denoting the half Pounds, and each half Pound into 2 other equal Parts, to expreſs the Quarters, and each Quarter into 8 equal Parts to mark

mark the half Ounces. The other Side of it *(viz.)* I K, is adjuſted for the weighing of Coal, and divided and marked with proper Lines and Characters. Obſerve here, that you cannot well divide this Side, till you know the Weight of the *Charcoal* that fills the Cylinder. For Example; if this Cylinder, that holds 4 ℔ of *Gun-powder*, holds only 2 ℔ of *Charcoal*, you muſt biſect the Side I K into two principal Parts, which may be ſubdivided in the manner we have already ſpecified. What I have here ſaid of *Charcoal*, muſt be underſtood with regard to *Sulphur* and *Salt-peter*, each of whoſe particular Diviſions may be marked upon the two other Sides of the ſquare Inſtrument abovementioned. This Inſtrument being adjuſted, may be uſed after this manner. For Example; if you would meaſure 2 ℔ of *Powder*, lift up your ſquare Inſtrument or Scale by the Ring at the end of it, till N° 2 exactly touches the Bottom of the Cylinder, then make it faſt with the Screw L, for fear it ſhould be preſſed downwards by the Weight of the *Powder*. Thus you may proceed in the Menſuration of any of the other Ingredients.

Fig. 19. is a *Searce*. Its Height is 3 Feet, its Length 3 ½ Feet, and its Breadth 4 ½ Feet. In the Body of this, at B, the Drawer C is contrived to go in and out, which is ' Foot high, 3 ¼ Feet long, and 2 ½ Feet broad; into this Drawer, through a fine Hair *Searce* or Sieve E, falls the *Meal*, which goes down the ſhelving Boards in the Box A, and which you may take out with a little Wooden Ladle, made for that Purpoſe, in the Form as you ſee *Fig.* E. D is a Croſs that holds the Sieve with four little Iron or Wooden Pegs or Pins, thereby making it ſerve with the more Convenience for ſifting. G is a Gooſe-Wing, or the Wing of any other Bird, for ſweeping the *Powder* together. H is a dry, ſmooth, wooden, mealing Table, which is on each Side incloſed with a Board, upon which your Ingredients for *Gun-powder* are to be ground and pulverized, or mealed. I, K, L, are Grinders, for grinding your Ingredients upon the above Table. M is another Table with a ſquare Hole in the Middle of it at N, which is ſhut up cloſe whilſt the Materials are grinding and pulverizing, but opened when you would withdraw your Ingredients.

OF THE

GREAT ART OF ARTILLERY.

PART *the* FIRST.

BOOK III.

Of ROCKETS.

ROCKETS have always held the first Rank of the several sorts of *Fireworks*, that have been for so many Years past in Vogue. The *Latins* called them *Rochetæ*, and the *Greeks*, *Pyroboli*; which last Denomination does not strictly agree with what we understand by a *Rocket*; inasmuch as πυροβελη properly signifies *Tela Ignita*, or *Fiery Darts*. The Italians call them *Rochette* and *Raggi*; the Germans, *Steigende Kasten*, *Ragetten* and *Drachetten*; the French, *Fuzees*; and the Poles, *Race*. So much for their *Names*; but as to their *Invention*, it is certainly as ancient, as the Construction of them is now common and familiarly known to *Pyroboliſts* and Fire-Engineers; which, tho' it may at first Sight appear very easy and simple, yet it requires the utmost Labour and Skill to bring them to Perfection, and is the first Task enjoined to the Disciples of * *Prometheus*, who would learn the artful Management of *Fire*. And truly I think it very reasonable that this should be their first Work, inasmuch as all the sorts of *Fireworks* exhibited for the public Diversion, such as *Fire-wheels*, *Cymetars*, &c. make but an imper-

* He is fabled by the Ancients to have made Man of Clay or Earth; and to have stolen Fire from Heaven wherewith he animated the Man he had made.

fect

fect Appearance without them. I therefore thought myſelf obliged in this *Third Book*, to inſtruct you in the due and proper Methods of preparing them; to ſhew you their different Forms and Conſtruction; and to diſplay the particular Uſe they are of.

CHAP. I.

Of Small and Middling Rocket-Moulds.

SORT I.

ROCKET-MOULDS are commonly made of Braſs or Lattin; or they may be turned of ſome hard Wood, ſuch as Cypreſs, Palm-tree, Cheſnut, Box, Walnut, Juniper, Wild Plumb, *&c.* But if you would have them formed of more valuable Materials, you may make choice of Ivory, or ſome fine *Indian* Wood. Workmen do not always obſerve the ſame Proportions in the Dimenſions of them, no more than the ſame exterior Ornaments in adorning them; and in this they verifie that Proverb, which ſays, *As many Men, ſo many Minds.* I ſhall now give you the Proportions of ſmall and middling *Rocket-Moulds*; (obſerve here that we call thoſe *Rocket-Moulds*, ſmall, whoſe interior Diameter or Orifice cannot receive a Leaden Ball or Bullet that exceeds 1 ℔: the middling Sort, are ſuch whoſe Diameters can admit Bullets from 1 ℔ to 2 ℔, or 3 ℔ at the fartheſt: and thoſe are called great *Moulds*, whoſe Diameters can admit of Balls from 2 ℔ to 100 ℔.) as to the *Moulds* of the larger Sort, I ſhall ſpeak of them in the following Chapter. The firſt *Mould* then is after this Faſhion. In *Fig.* 20. I ſup- Fig. 20.
poſe that the interior Diameter of the *Mould (viz.)* A, B, is equal to the Diameter of a Leaden Bullet of 1 ℔; and that the Height of the *Mould* from Y to E, is 7 of the aforeſaid Diameter; and that from E to G is the Height of the Breech or Bottom, which ſtops up the *Mould* whilſt the *Rocket* is driving; which is 1 ½ Diameter. You muſt here take Notice, that it is the common Practice of *Pyroboliſts* to meaſure the hollow Cylinders or Orifices of *Rocket-Moulds* by the Diameters of Leaden Balls. To return then to our Subject: upon the Bottom you have a ſolid Cylinder whoſe Diameter is C, D, or $\frac{12}{12}$ of its Height, which is 1 Diameter of the Orifice: This Cylinder is crowned with the Hemiſphere or Half-Bullet L O P M of ½ of the ſame Diameter. As to the Ornaments in general, they muſt be left to every one's particular Fancy; but we moſt commonly affect an Imitation of the Columns of Architecture. In our *Figure* the Height of the Capital is one Diameter. Now to form the ſeveral Members of it; this ſame Diameter being ſet off from Y towards G, upon the Line Y, G, you ſhall triſect it into 3 equal Parts; each of which

which ſhall be ſubdivided into other ſmaller Parts. Moreover from F to K you ſhall ſet off one Diameter for the Members of the Baſe. I ſhall be more particular upon this Head when I come to the Explanation of the following *Figure*, which is more artfully wrought, and more adorned than this: But in the mean time you may take all the Proportions of this with a pair of Compaſſes. The Thickneſs of the *Mould* from A to W, and from B to X, as likewiſe from S to Z, and from A a to R, and then down to T and U, is 1 ½ a Diameter of the Orifice of the *Mould*; but from F to C it is a whole Diameter, and in ſhort from G to H it is 3 of the ſame Diameter. I is an Iron Pin that runs through the Subſtance of the *Mould*, and through the Cylinder upon the Bottom, to keep them together whilſt the *Rocket* is driving.

SORT II.

Fig. 21. In *Fig.* 21. the Height of the whole *Mould* G, E, is 9 of the Diameter A, B, two of which are taken up by the Bottom. A, B, C, D, is the Hollow of the whole *Mould.* A, N, or G, L, is the Height of the Capital of it, and is 1 ⅛ of the Diameter A, B. Now this Diameter being divided into 80 equal Parts, it will expedite our taking the Proportions of all the particular Members of the Capital. Firſt then, in going downwards, the Sloping Corniſh ſhall be 7 Parts high; the Liſt of it 3; the Eehinus reverſed 7; the Liſt of that 3; the Cymatium or Doric Gule-revers'd 7; the Liſt of it 3; the upper Band 10; the Face 10; and the nether Band 10 alſo; the Reglet 2; the Apophyge 10; the upper Ring 2; the Aſtragal 4; and the nether Ring or Neck of the Column 2: the Projectures of one and the other Liſt or Fillet is 5 Parts; as is alſo the Retreat of the Face. The half Diameter of the Doric Gula ſhall be taken upon the Perpendicular of the Face, and upon the Reglet that is under it; but the Semi-Diameter of the reverſed Echinus, ſhall be taken upon the Perpendicular, that deſcends from K upon A, G; as for A, K, it ſhall be 30 Parts of the Diameter. The Semi-Diameter of the nether Echinus anſwers to its own Height. The right Line U, F, terminates the Projecture of the Liſts or Rings on one Side, and the Line I, E, on the other; but that would be encreaſed if from B and U, and A and I you allow 60 Parts of the Diameter. Know alſo that theſe right Lines determine the lower Part, or Baſe and Pedeſtal of the *Mould.* The upper Thickneſs of the *Mould* as far as the Aſtragal is ½ a Diameter of the Orifice or 40 Parts, but the Lower Thickneſs of O, P, upon the Baſe is 50 of the ſame. All the Thickneſs of the Middle or Shaft of the *Mould* is terminated by the right Line M, O, but the Thickneſs of the Baſe by that other Line E, W, upon E, I; the whole Baſe is 1 ½ Diameter in Height. Let us now ſpeak of the ſeveral Members going upwards: Firſt then, the Plynth is 110 Parts high; the little Echinus reverſed 8; the Liſt under it 2; the Doric Cymatium 6; the Reglet 2;

the

the Tore 6; the Liſtel 2; the Projecture of the Liſts, and the Semi-Diameters of the Echinus reverſed, and Doric Cymatium, anſwer to their reſpective Heights. The Members of the Pedeſtal are the little Tore which is 3 Parts, and the Reglet but two Parts only. The Diameter of this (*viz.*) E, F, is 3 of the Diameter aforeſaid. The Cylinder C, Q, R, D, upon the Pedeſtal is one Diameter in Height, and its Thickneſs Q, R, is 78 Parts of the ſame Diameter: The Diameter of the Hemiſphere upon the Cylinder is $\frac{3}{4}$ of the Diameter of the *Mould*, and conſequently 60 Parts of it. This is what I have to ſay of the leſſer *Rocket-Moulds*, as well of the leaſt as the middling Sorts. If therefore you would ſucceed in your Attempts in this kind of Work, you muſt take care nicely to obſerve the Proportions we have laid down; but indeed the outward Embelliſhments may (as we have already ſaid) be alter'd, and varied according to the Fancy of the Perſon who makes them. Beſides theſe two Figures, I preſent you a third *(viz.) Fig.* 22. by means of which we may determine Fig. 22. the proper Dimenſions and Ornaments of great *Rocket-Moulds*; and from thence find the due Proportions of thoſe of leſſer Sizes. That which I have given in this *Figure* is but of one *Loth* or half Ounce; and from thence we may find out *Moulds* for the $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ Part of a *Loth* after this manner. The Baſe of the *Figure* A B, is divided according to a Cubical *Ratio*, and upon the Points of Diviſion you have Perpendiculars erected, which are terminated by the Secant C, D, which muſt be produced from C to D; provided that B C, which is the Height of a *Mould* of one *Loth*, be 9 Diameters of its Orifice or hollow Cylinder; and then all the Perpendiculars may be drawn of the ſame Proportion as to Height.

Obſerve here that the Semi-Diameters or *Radii* of the Quadrants, and the Lines produced to the Extremities of them, in the Figure of the *Mould* of one *Loth*, denote the Thickneſs of the *Mould* in the Places where their Centers are ſituated. To conclude; what we have here ſaid concerning the Proportions of ſmall *Rocket-Moulds* found out by means of a larger, may be inverted; and you may reciprocally have the Proportions of large *Moulds* by means of one of the ſmaller ſort.

CHAP. II.

Of great Rocket-Moulds.

WE have in the foregoing *Chapter* limited the Proportions of ſmall and middling *Rocket-Moulds*; having allowed them 7 Diameters of their hollow Cylinders without reckoning the Bottom: And it muſt not be wondered that I have taken this Liberty; my continual Experience, and the moſt valuable part of my Life which has been devoted

to this kind of Study, having ſufficiently confirmed my Practice, and convinced me that they neither can nor ought to be made otherwiſe, if you would have them to anſwer as they ſhould: And the Authority of the moſt modern *Pyroboliſts* will ſupport me in what I have laid down; for to ſpeak my Mind, it is in vain for you to ſeek after theſe nice Proportions in the Writings of the Ancients; for if you compare them all together (I aſſure you, I have now before me at leaſt a couple of Dozen of Authors who have written on *Pyrotechnics*,) you will find them not only widely different from one another, but likewiſe entirely contrary to my Obſervations, and (if I may ſo ſay) Diametrically oppoſite to my Practice. But be this as it will, I ſhall give you ſome of their Rules and Directions to confirm my Aſſertion. Firſt then; *Brechtelius* in the ſecond Part of his *Pyrotechnics* Chap. IX. ſaith, That the *Mould* of a *Rocket* of one ℔, ought to be the Height of 2 Fingers, and the Diameter of its hollow Cylinder the Breadth of two of the ſame. Here the Diameter and Height are in a Subquadruple Proportion to one another; but he increaſes his *Moulds* by adding ſucceſſively ¼ of a Finger both to their Breadth and Height. From this Progreſſion this confuſed Diſproportion will ariſe, That a *Rocket-Mould* of 17 ℔ will have its Diameter in a † ſubduple Proportion to its Height; and the Diameter of one of 100 ℔ will be within a little more than ¼ of its Height: Thus the Diameter and Height will be to one another as 106 is to 131; but as this Number is a Surd, it cannot be reduced to the loweſt Term. However the Height will be to the Diameter in a ſuperpartient Proportion or as 1, $\frac{11}{105}$ Parts. You muſt here again obſerve that the Diameters of his *Moulds* are not increaſed in a Cubical *Ratio* as they ought to be, but by an uniform Progreſſion (namely) by the Addition of ¼ of a Finger; and that the Heights of his *Moulds* are moſt ſadly proportioned to their Diameters: Upon the whole, I am perſuaded that this *good Man* never made any *Rockets* in his Days, that exceeded one or two ℔; for it would have been impoſſible for him to make ſuch ill-contrived Things depart, or oblige them to mount up, they being almoſt as broad as they were long. This is not the leaſt Defect when he ſays, that the Diameter of a *Mould* of one ℔ ought to be 2 Fingers; for it being certain that 2 Fingers exactly conſtitute the Diameter of an Iron Bullet weighing one ℔ of *Noremberg*; it will follow, that the Diameter of a *Mould* of 100 ℔ will according to his reckoning be 26 Fingers and ½. Now if we ſuppoſe this Diameter to be that of an Iron Bullet, it ought to weigh 2326 ℔ 3 Ounces: But if we ſuppoſe it to be the Diameter of a Leaden one (in purſuance to the preſent Practice, as I before hinted) ſuch a Bullet ſhould weigh 3350 ℔ 13 Ounces. By this, any one may readily perceive the wretched Miſtakes *Brechtelius* has fallen into, and how abſurdly he reaſoned upon this Head; and conſequently take care not to mind what he

† This is right. The *French* has it Subdecuple, which is impoſſible.

teaches.

teaches. *Johannes Schmidlapius* is the ſecond of thoſe ancient *Pyroboliſts* I ſhall mention, who lived ſome time before *Brechtelius*. He would have the *Moulds* of all *Rockets* be the Height of 6 Diameters of their Orifices; as for the Diameters themſelves he increaſes them after this manner. He divides the Diameter of the firſt *Mould* into five Parts (which he ſuppoſes in his Figure to be equal to that of a *Loth* or half Ounce of Lead) and adds two of thoſe Parts to the firſt Diameter to conſtitute that of the ſecond *Mould*. This is the Order he obſerves in the Conſtruction of *Moulds ad Infinitum*. But to ſpeak my Mind as to this Matter; he allows too great a Height to his larger *Moulds*, and has aſſigned no certain fixed Meaſure for the Diameters agreeing with the Diameters of Leaden or Iron Bullets. However I have often tried, and found that Diameters increaſed after the manner he preſcribes, obſerve the following Progreſſion with regard to Leaden Bullets; (namely) the ſecond Diameter containing $\frac{7}{5}$ of the firſt, is exactly the Diameter of a Leaden Bullet of 3 *Loths*: The Third containing $\frac{7}{5}$ of the ſecond Diameter anſwers to that of a Leaden Bullet of 7 *Loths*; the Fourth of $\frac{7}{5}$ of the third Diameter is equal to the Diameter of a Leaden Ball of 20 *Loths*: The Fifth containing $\frac{7}{5}$ of the fourth Diameter is equal to that of a Leaden Bullet of one ℔ 22 *Loths*: The Sixth $\frac{7}{5}$ of the fifth Diameter is equal to the Diameter of a Leaden Ball of 4 ℔ 26 *Loths*: The Seventh $\frac{7}{5}$ of the Sixth, to the Diameter of a Leaden Bullet of 13 ℔: The Eighth $\frac{7}{5}$ of the Seventh, is the Diameter of a Leaden Ball of 35 ℔: And to conclude; the Ninth $\frac{7}{5}$ of the Eighth is equal to the Diameter of a Leaden Bullet of 98 ℔. From what I have here been ſaying, it follows, that this Author has not aſcertained any fix'd or limited Proportion to increaſe the Diameters. But this is pretty excuſable, and we do not condemn him entirely; inaſmuch as he has taken upon him to ſhew us, how to make *Rockets* of ſuch Sizes, that a ſmall one may exactly fill up the Hollow of a larger. This may be eaſily conceived; for if (for Example) you take the Diameters of 9 *Rockets*, beginning from one *Loth*, to ſuch a Number of Pounds as we have ſpecified above; the Eight Firſt being put into one another, they will all very conveniently go into the ninth and laſt *Rocket*, the Diameter of whoſe Orifice is equal to that of a Leaden Ball of 98 ℔: But you muſt take care that the Paper of your ſmall Caſes, and the Wood of the great ones do not exceed $\frac{1}{5}$ of their reſpective Diameters. Theſe two *Pyroboliſts* I have now been ſpeaking of, are the moſt ancient I can recollect; the firſt having printed his *Pyroboly* about 59 Years ago; and the other publiſhed his about 90 Years ſince. Amongſt thoſe of the lateſt Date, we find *Diegus Ufanus*. This Author, in Chap. XXVI. of the third Treatiſe of his *Artillery*, determines the Heights of little and big *Rockets* to be 6 or $7\frac{1}{2}$ of their Diameters: Therefore in this, he comes pretty near to the Proportions of our ſmall *Rockets*; but differs widely from our Rules with regard to Great ones. But the moſt modern and moſt excellent *Pyroboliſt*

roboliſt of all thoſe I ever read (without diſparaging *Adrian Roman*, *James Valhauſe*, *Furtenbach*, *Frontsbergue*, and ſeveral other worthy Perſons, who have treated learnedly on this Subject) is one called *Hanzelletus Gallus*, who by his Name ſhould be a *Frenchman*: This Author makes the *Moulds* of all his *Rockets* from one *Loth* to 6 ℔ to be 6 Diameters, and it is in this that he diſagrees the moſt from us: But as for great *Rockets* (in which conſiſts the whole Secret of the Art) he ſays, it is ſufficient if they be 4, 4 $\frac{1}{2}$, or 5 Diameters in Height; here he approaches very near to our Proportions. As for our Obſervations on the Conſtruction of great *Rockets*, we here preſent you
Fig 23. with a *Mould* (*Fig.* 23.) calculated for the making thoſe of 20 ℔, I having ſuppoſed the Diameter of the hollow Cylinder A, B, to anſwer to the Diameter of a Leaden Bullet of that Weight. The Height A, C, or B, D, is 6 $\frac{7}{100}$ Diameters: And is taken from the following *Table*, where 86 corresponds exactly with 20 ℔; that is, that the Diameter A, B, being firſt divided into 100 equal Parts, 86 of them were taken off by the Compaſſes, and repeated 7 times from A or B, towards C or D, to conſtitute the Height of the *Mould* A C, or B D. For as the Diameter compoſed of 100 equal Parts being 7 times repeated gives the Height of *Rocket-Moulds* of one ℔, ſo 86 being 7 times repeated gives the Height of a *Mould* that is 6 $\frac{7}{100}$ of its Diameters. Thus you may find the Heights of all *Moulds* whoſe Diameters anſwer to the Diameters of Leaden Balls as far as 100 ℔. But if you would have them by the Rule of Three, ſay, as 100 is to 7, ſo is the Number over-againſt your Number of Pounds in the following *Table* to a fourth Number. Or you may divide the Diameters of the hollow Cylinders of the *Moulds* into 100 equal Parts, and take as many Parts from that Number, as anſwer to the Number in the *Table* oppoſite to the Number of Pounds anſwering neareſt to the Diameter of your *Mould*; a ſevenfold Repetition of which will give the due Height of the *Mould* you would make. The ſame it is with the Diameter of a *Mould* of 100 ℔, which if it be divided into 100 equal Parts, and with a pair of Compaſſes you take † 57 of thoſe Parts; a ſevenfold Repetition of them will give the Height of a *Rocket-Mould* of 100 ℔, and which will be 4 of its own Diameter *minus* $\frac{1}{100}$ or 399 of ſuch Parts as its Diameter is divided into.

From hence it is evident that I have not fallen into an Extreme of too much nor too little with regard to theſe Proportions; for I have neither increaſed the Heights of *Moulds* by an uniform Progreſſion after the

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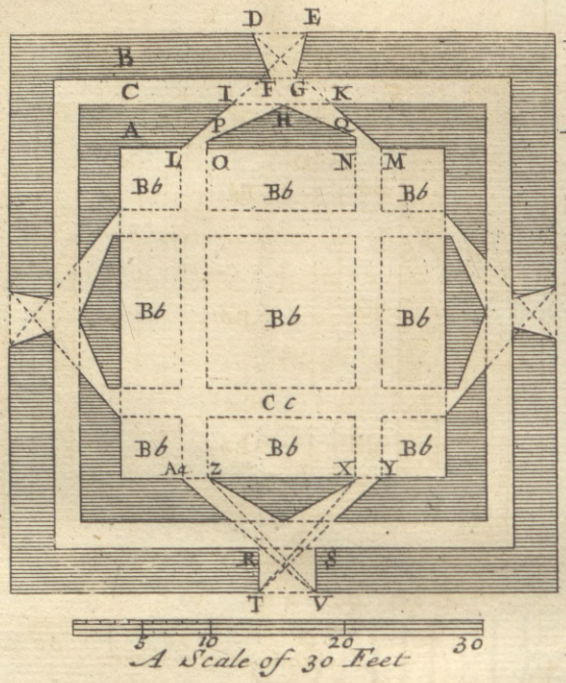
† Example: as 100 : 7 : : 57

$$\frac{\overset{7}{\overline{1|00|3|99}}}{3} = 3\frac{99}{100} = 400 - \tfrac{1}{100} = 399$$ Diviſions of the Diameter.

manner



A Scale of 30 Feet

Fig. 17.

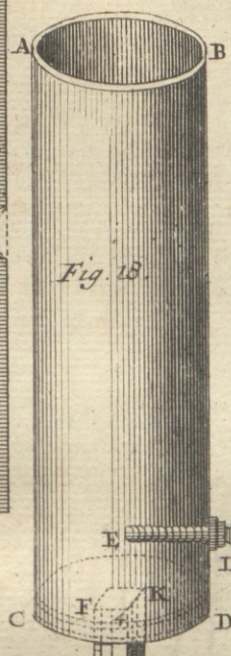
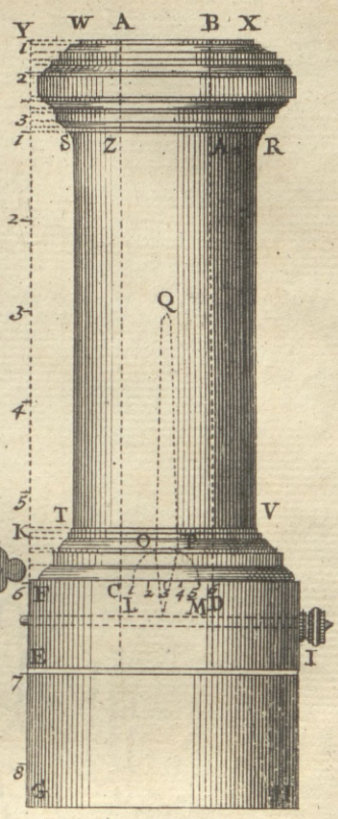


Fig. 18.

Fig. 20.



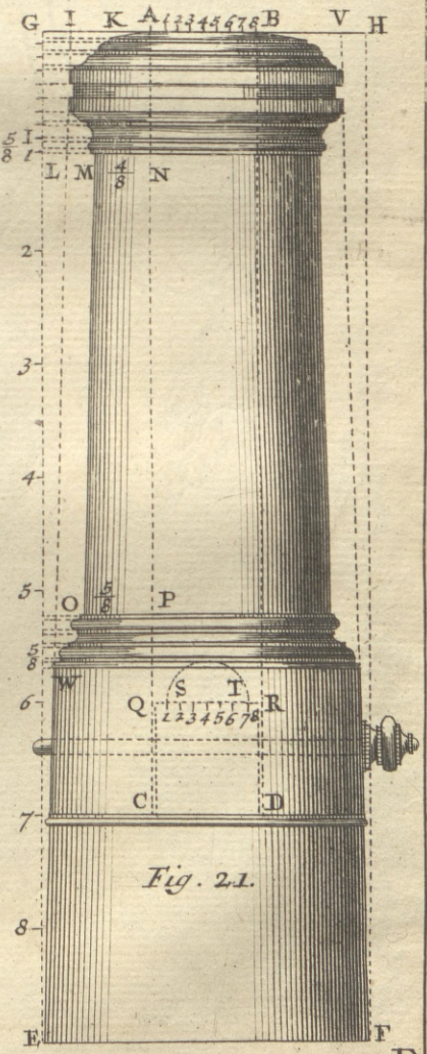


Fig. 21.

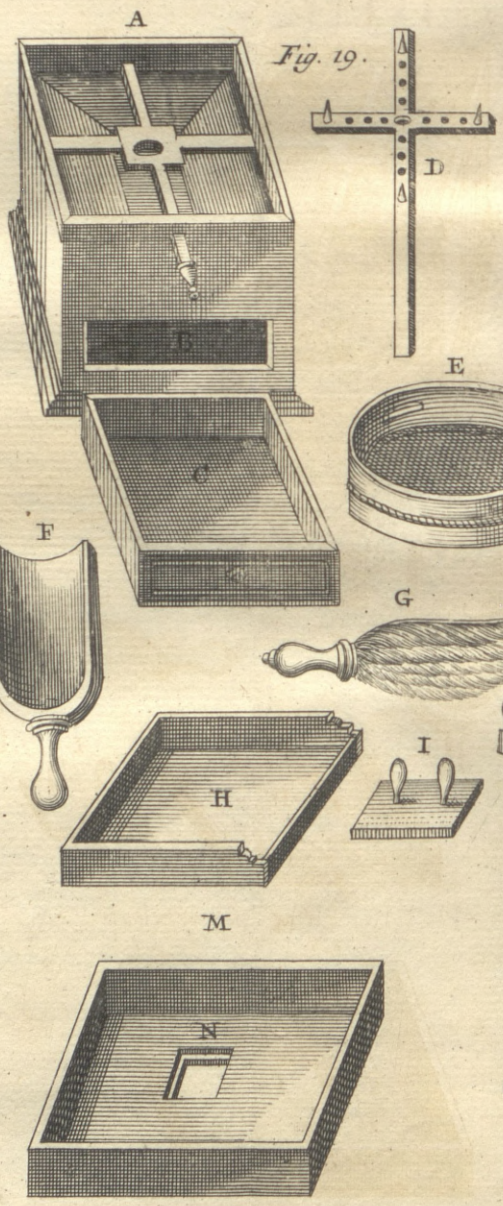


Fig. 19.

P.F. sculp.

D

manner of *Brechtelius*, nor laid down one universal Dimension of Height with respect to the several Diameters; nor always kept to 6 and 6 ½ Diameters, like *Diegus Ufanus* and *Schmidlapius*. Upon the whole, I have not augmented the Diameters according to the Methods of *Schmidlapius* and *Brechtelius*, by dividing them into 5 Parts, and adding 2 of the like Parts to them to constitute the Diameter of the subsequent *Mould*, nor by adding ¼ of a *Finger*, as they have done; but I have decreased the Heights of *Moulds* proportionably to the Increase of their Diameters in a Cubical *Ratio*; so that I believe no one can tax me with having committed a Mistake upon this Head.

Now that you may have no manner of doubt upon you with relation to what I have just been saying, I here-under present you with a little *Table*; which has not been calculated so much by Theory and Speculation, as confirmed and ascertained by my long Practice; which, together with the many Losses I have sustained, and the daily Expences I have been at in my Prosecution of this Study and Art, gave Life to my Invention.

A Table *of Heights for great* Rocket-Moulds.

Pound Weights of Leaden Bullets whose Diameters answer to the Diameters of *Rocket-Moulds*.	Hundredth Parts of Diameters in a subseptuple Proportion to the Heights of *Moulds*.
1	100
2	98
4	96
6	94
8	92
10	91
12	90
15	88
20	86
25	84
30	82
35	80
40	78
45	77
50	75
55	73
60	71
65	69
70	67
75	66
80	64
85	62
90	61
95	59
100	57

Fig. 23. This is not enough: Let us return again to our *Figure*, and we ſhall find ſtill ſomething farther relating to this Proportion of *Moulds*. E X then, is the Height of the Baſe of one Diameter of the Orifice or hollow Cylinder: X, C, is the Thickneſs of the *Mould* throughout, which is $\frac{1}{3}$ of the ſame Diameter; E, F, is the Solidity of the Baſe or Bottom equal to 1 $\frac{1}{7}$ of the aforeſaid Diameter; B, P, or A, P, is the Capital of the *Mould* whoſe Members are reverſed or go upwards: The Liſt is $\frac{10}{70}$ of the Diameter in Height; the Echinus reverſed $\frac{15}{70}$; the Reglet is $\frac{5}{70}$; and in ſhort, the ſloping or inclining Cornice is $\frac{8}{70}$. Q Q ſhew the Thickneſs of the Subſtance of the *Mould*; P P denote the Hollowings wrought in it, which muſt be woulded, or ſecurely girt round with glued Cord, to prevent the *Mould* from ſplitting whilſt you drive the *Rocket*: Theſe Hollowings are $\frac{1}{7}$ Diameter deep. Beſides this, there is a Wooden Cylinder joining to the Bottom, which is the Height of one Diameter; but this Dimenſion for it will not always obtain; for in great *Rocket-Moulds* from 40 to 70 ℔, it muſt be but $\frac{1}{3}$ of a Diameter, and in the reſt till you come to 100 ℔, it muſt be but $\frac{1}{2}$ Diameter. This Cylinder muſt be crowned with an Hemiſphere, or half Bullet, whoſe Circumference is deſcribed from the Center N, and whoſe Diameter is equal to ' of a Diameter of the Orifice or hollow Cylinder aforeſaid. R, is a ſmall Cavity where a Ring of ſome Metal is commonly faſtened. W, is an Iron Pin that keeps the upper and under Part of the *Mould* together. As to any thing elſe, that may be farther remarkable in this Figure, we ſhall ſpeak of it in the next Chapter.

Fig. 24. In *Fig.* 24. you have a *Mould* for the Conſtruction of Paper *Petards* (in *Engliſh*, *Crackers*) which I ſhall ſhew you how to adjuſt, and make uſe of in the ſubſequent Chapters. I would only have you obſerve here that the Height of theſe *Moulds*, which is A, B, C, D, ought to be 4 Diameters of their hollow Cylinders, and that the Height of the Bottom I, K, and of the ſolid Cylinder G, E, or H F, is one Diameter; in ſhort, the upper Surface of this Cylinder, E F, muſt be a perfect Plane, except where it is heightened by the Hemiſphere.

CHAP. III.

Of ſeveral Inſtruments for Making, Choaking and Driving all Sorts of Rockets.

YOUR *Rocket-Moulds* being thus adjuſted, according to the Proportions laid down in the foregoing Chapters, it will be neceſſary that you be provided with ſeveral other Utenſils for carrying on your Work. In the firſt Place then; for ſmall and middling *Rockets* you muſt have a

Wooden

Wooden Cylindrical *Driver* or *Rowler* (for very ſmall ones we uſe a little Iron Rod) whoſe Length ſhall be equal to the Height of the *Mould*, and its Thickneſs $\frac{6}{8}$ of the hollow Cylinder. See the Repreſentation of it in *Fig.* 25, where the Line A B is the Length of 7 Diameters of the hollow Cylinder of the *Mould* of the ſecond Model in *Fig.* 21. the lower end of it terminates in an Hemiſphere, whoſe *Semi-Diameter* is $\frac{3}{8}$ of the Diameter of the hollow Cylinder (for it is proper this *Rowler* or *Former* ſhould be a little longer than the Height of the *Mould)* and the Thickneſs of it C D, is $\frac{6}{8}$ of the ſame Diameter. E is the Handle of it, which ought to be a Hand's breadth in Length. Upon this *Rowler* or *Former* you ſhall paſte or glue together, as nicely as you can, ſome good ſtrong Paper, till by the ſeveral Turns of it your Caſe has acquired the Thickneſs of $\frac{1}{8}$ of the Diameter aforeſaid; notwithſtanding that in the firſt *Mould*, *Fig.* 20, I have ſuppoſed this ſame Thickneſs to be $\frac{1}{6}$ of the Diameter; for then it is neceſſary that this *Rowler* or *Former* ſhould be $\frac{7}{8}$ of the Diameter. But for great *Rockets* that are made of Wood, ſuch as you ſee in I K *Fig.* 23, the Thickneſs K B, or A I is $\frac{1}{7}$ of the Diameter, or a very little leſs; for there is always a ſmall Space, as S, left between the Concavity of the *Mould*, and the Convexity of the *Rocket*, that there may be room for a pretty ſubſtantial Woulding of ſtrong Thread or Cord, with which the Outſide of the *Rocket* is commonly reinforced. The Neck or lower Part, G O, of the *Rocket* in the ſame Figure is $\frac{1}{3}$ of a Diameter. Now if your *Rockets* are made of Wood, you cannot uſe the *Driver* or *Rowler* I have been deſcribing above, which is deſigned only for Paper or Canvaſs *Rockets*; but for Wood it muſt be $\frac{1}{7}$ of a Diameter, and its Length ſhall be equal to the Height of the *Mould*, *minus* the Height of the Cylinder upon the Bottom. Upon ſuch a *Rowler* or *Former* I have made Paper and Canvaſs *Caſes* for *Rockets* of 20 or 30 ℔ and upwards, and after having woulded and ſecured them round with glued Packthread, I have put them into the Nave of a Cannon Wheel, and having encompaſſed them firmly with dry Sand, and faſtened them with Coins, and fixed a Bottom under them, I have in that poſture driven them very conveniently.

Fig. 25. Fig. 21

Secondly, you muſt have a *Rammer* or *Driver* different from this, for charging your *Rockets*, which may be conſtructed two ſeveral ways; for if you intend to bore your *Rockets* after they are driven, (as we ſhall hereafter obſerve) you ſhall give it the Form you ſee repreſented in *Fig.* 26. Its Length A B, ſhall be equal to the Height of the *Mould*, and its Thickneſs B C ſhall be *minus* $\frac{1}{12}$ equal to the *Axis* C, D, in the firſt *Figure*, and ſhall be perfectly ſmooth and round, that it may the more conveniently drive or ram the Compoſition, and conſolidate it in the *Caſe* or *Coffin*. But if you would drive your *Rockets* upon Copper or Iron Needles or Piercers, ſuch as O P Q, and L M H, in *Fig.* 20. and 23, your *Driver* or *Rammer* ſhall be of the very ſame Dimenſions with the Hollow of your *Rocket-Caſe*, or *Coffin*, and ſhall have a Cavity in it

Fig. 26. Fig. 25. Fig. 20. and 23.

that

that exactly fits the Piercer or Needle; to the end that when you drive your *Rockets* the Needle may have free Access into the *Driver*, and that consequently the Composition may be driven and compacted in a firm Body all round it. You must here observe, that if the Needle is fixed in the Bottom of the *Mould* (which it must of necessity be, if you would have it in a perpendicular Position, and exactly in the middle of the *Rocket*, upon which much depends) you must have another Bottom without a Needle for adjusting the Paper Cases, and a *Driver* or *Rammer* according to the first Model; or a hollow *Driver*, as we said before.

Fig. 27. Fig. 23. In *Fig.* 27. (for Example) B A, is the Length of the *Driver* equal to the Height of the hollow Cylinder of the *Rocket* represented in *Fig.* 23. its Breadth B C, is equal to the Diameter of it, or a little less, as we have already said: And D, F, E, is the Hollow that receives the Needle.

Besides these two *Rammers* or *Drifts*, *Pyrobolists* have a Third equally necessary for driving *Rockets* upon Needles. You may see the Form

Fig. 28. Fig. 23. of this in *Fig.* 28. where its Length A B is equal to the Height of the *Rocket* above the Point of the Needle; that is, from L to I K the Mouth of the *Rocket-Case* or *Coffin* in *Fig.* 23. but its Breadth or Thickness B C, is exactly equal to that of the first *Driver*. This is for driving the solid Part or the *Head* of the Composition in the *Rocket*; and the Handles D and G shall be fashioned as you see in the *Figures*: The Ends H and E shall have Brass Rings round them, especially when designed for the use of great *Rockets*, to prevent their spreading or splitting by the Violence of the Driving.

Fig. 29. *Fig.* 29. represents a Leather Belt or Thong, with its Buckle, Copper Ring, and Iron Hook moveable to and fro upon the Belt. It is with this that the *Pyrobolist* girds himself when he would choak his *Rockets*.

Fig. 30. *Fig.* 30. you have another Hook with a Screw, which being screwed into any Tree, or piece of Wood firmly fixed in a Building or otherwise, serves together with the First, to draw the Cord which is about the

Fig. 31. Fig. 32. and 33. Neck of the *Case* after the manner that you see in *Fig.* 31. *Fig* 32. represents the Cord, and *Fig.* 33. is a Wooden Taper-bit for opening the Orifice, when the Neck is *choaked* too close.

We have another Way of *choaking* middling *Rockets (viz.)* by a Wooden Sheave or Shiver turning upon an Iron Pin or *Axis*, over which is a Cord, one End of which is fastened to an Iron Ring, and the other to the End of a Treading Board or Treadle, upon which the *Pyrobolist*

Fig. 34. presses with his Foot, as may be seen in *Fig* 34.

But for the *choaking* of great *Rockets*, you may use the Contrivance

Fig. 35. in *Fig.* 35. with its endless Screw, and Handle to turn it (A) together with its Hook and Iron Ring to which the Cord is tied to *choak* the *Rocket*, after having put into the Neck of it a Cylinder done round with Hair or

Fig. 36. Wool, and crowned with an Hemisphere as may be seen in *Fig.* 36. which serves properly for forming a round Cavity in the Neck of

the

the *Rocket*. *Fig.* 37 is ſometimes uſed to the ſame purpoſe; it being an Iron *Inſtrument* with Hollows cut on each Side of it, into which you put the Necks of your *Rockets*, in order to compreſs or *choak* them. There are other ways of *choaking* Rockets, beſides thoſe I have mentioned. As for Example; you may faſten any Handſpike or Lever to any Wall, Pillar, or Rafter, and then pull upon the *Choaker* either by a great Force or Weight. But as theſe Ways are out of Uſe, and aukward in themſelves, I ſhall paſs them over, and proceed to a Deſcription of ſuch *Inſtruments* and Things as are more neceſſary for us to be acquainted with. Fig. 37.

Fig. 38 repreſents a *Copper Plate* for making a *Charger*, as you ſee in *Fig.* 40. I have given it ſuch Proportion, that its Length from A to B is 1 $\frac{1}{3}$ Diameter of the hollow Cylinder of the *Rocket*; and its Breadth C D equal to 2 of the ſame Diameter; and have ordered it ſo, as to terminate in a Semi-Circle at the charging End, and have to its Length and Breadth added another Diameter reſpectively, that it may be conveniently fitted to a little Wooden Cylinder or Handle to which it may be faſtened with ſmall Nails; for let the Thickneſs of the Handle be equal to one Diameter, and the Rotundity of its Convex Surface will be 3 Diameters, that is, equal to the Breadth E F. The Length I have aſſigned for this *Plate*, ought to be obſerved in making *Chargers* for little and middling *Rockets*; for I have often experimented, that *Chargers* made in this Proportion contain exactly ſuch a quantity of Compoſition whoſe Height fills one Diameter of the hollow Cylinder of the *Rocket*. Now it will be ſufficient, if you put in as much Compoſition at a time as being well driven with a Wooden Mallet will take up the Space of half a Diameter aforeſaid. But in driving of great *Rockets* you muſt put in leſs Compoſition at a time; for it will be ſufficient if you put in half of what we have directed with reſpect to ſmall *Rockets*; and conſequently the *Plate* with which you would make a *Charger*, that ſhould hold but juſt ſo much Compoſition as to fill up half the Space we have been mentioning of the hollow Cylinder of a great *Rocket*, and which being well driven ſhould be only $\frac{1}{4}$ of a Diameter in Height, ſhould have its Length equal to but one Diameter. As for the Size of the Handle to which the *Plate* is to be fitted, it ſhall be in ſuch Proportion as we have above directed. Fig. 39. Fig. 40.

In *Fig.* 39 you have the Repreſentation of a Wooden *Mallet* with its Handle. It ſhould be made of ſome hard, heavy Wood, ſuch as Elm or Birch Root; its Length or Height ſhall be 1 $\frac{1}{2}$ of its Breadth or Thickneſs, which ſhall be proportioned to the hollow Cylinders of *Moulds* after this manner. From 100 ℔ down to 50 ℔, your *Rockets* ſhall be driven with *Mallets*, the Diameters of whoſe Thickneſs are equal to the Diameters of the hollow Cylinders of the *Moulds*: But all other *Rockets* down to 10 ℔, with a *Mallet* whoſe Diameter is equal to that of a Leaden Bullet of 50 ℔. In ſhort, all from 10 ℔ to 1 ℔, ſhall Fig. 39.

be driven with a *Mallet* whoſe Diameter is equal to that of a Leaden Bullet of 40 ℔; and as for thoſe from 1 ℔ to 8 *Loths* or 4 *Ounces*, they ſhall be driven with a *Mallet* whoſe Diameter is equal to that of a Leaden Bullet of 20 ℔. Or to do better, and ſpeak more plainly; all your *Mallets* from 100 ℔ to 10 ℔ ſhall have their Diameters equal to the Diameters of the Orifices of their reſpective *Moulds*; which done, you ſhall make a Cavity in the Ends of them which you do not ſtrike with, into which you muſt pour as much melted Lead as may be ſufficient to make them as heavy as the Bullets by whoſe Diameters the Orifices of their reſpective *Moulds* are meaſured. We may with a *Mallet* of 10 ℔ drive all other *Rockets*, down to 4 ℔; and from 4 ℔ to 1 ℔ with a *Mallet* of 6 ℔; and from one ℔ to ℔ ſs with a *Mallet* of 4 ℔. In ſhort, from ℔ ſs to 4 *Loths*, or 2 *Ounces*, the *Mallet* ſhall weigh 2 ℔.

As for the driving of very ſmall *Rockets*, or (as we call them in Engliſh) *Squibs*, you need not be ſo nice in the Preparation of them. I have known ſome modern *Pyroboliſts* who aſſigned a determinate Number of Strokes, and *Mallets* of various Weights, for the ſeveral Compoſitions they uſed in driving a *Rocket* of any one particular Size; ſo that they changed the Weight of their *Mallet*, and varied the Number of Strokes, according to what Compoſition they uſed. But in my Opinion this Rule is more ridiculous and whimſical, than uſeful; therefore ſetting theſe Abſurdities aſide, this is the moſt certain and beſt Method that can be purſued with regard to this Matter; (namely) When you pour Compoſition into your *Rockets*, it ſhall not be too dry, for fear of its diſperſing, and flying about in a ſubtile Meal or Duſt whilſt you are driving it; but ſhall be a little moiſt, to the end that it may collect the better, and be the more ſolidly compreſſed in the Caſe or Coffin of the *Rocket*. You may believe, it is impoſſible to aſcertain any determinate Number of Strokes that may be exactly ſufficient in driving it; and therefore we can only ſay that the Compoſition ought to be driven and beaten till it is become as hard as a Stone. As for thoſe Particles that are dried by the Violence of the driving, and will not unite with the reſt; they ſhall from time to time be turned out, by ſtooping the *Mould*, and ſtriking it briskly to make them fly abroad. I muſt farther caution you, to ſtrike the *Driver* with an equal Number of Strokes, as often as you pour your Compoſition into the Caſe; and let your Blows be given with an uniform Force, neither too violently nor too gently, but with moderation, and making a ſhort Pauſe after each Blow. The Weight of the *Mallet* ſhall be as we have ordered above. The Compoſitions ſhall be taken and uſed in Proportion to the Diameters of *Rockets*, as we ſhall obſerve in the following Chapter; and beware of uſing an hundred different Sorts of Compoſitions, for one or any particular ſized *Rocket*, and only ſtick to one or two, which you ſhall by Experience find to be the beſt. To this I ſhall add, that ſuch Ingredients as are too dry, imperfectly mealed, and negligently ſearced, or

that have too much Charcoal amongſt them made of any hard, groſs Wood, cannot be conſolidated without a great deal of Labour, and therefore muſt be driven much longer than thoſe which are free from theſe Defects. I muſt furthermore inform you that the ſtronger the Compoſition is, ſo much the more ought it to be driven; that the Fire may meet with the more Obſtruction in conſuming it, and that by means of its ſolid Conſiſtence the Action of that Element may be reſtrained. But this, on the other hand, is apt to throw us into a great Inconveniency; for the Violence of the driving greatly adds to the Strength of the Compoſition, and indues it with I know not what extraordinary Virtue which it had not before; therefore muſt you keep this Sentence in Mind, as a general Rule to be obſerved in our Art (namely) *Serva Mediocritatem:* Avoid Extreams, and keep in the middle Path, leſt by running into either Exceſs, your Labour proves vain and abortive. But let us have done with this Digreſſion, and reſume our Subject. Say we then, that the longer the Handle of the *Mallet* is, and the higher the *Pyroboliſt* lifts up his Arm to ſtrike, with ſo much the more Velocity and Power will the *Mallet* fall upon the Head of the *Driver* that is beneath. So that a *Mallet* of 10 lb only will act much more violently, and deſcend with greater Force, than one of double that Weight, but whoſe Handle is only Subdecuple of the Firſt. If you would know the Cauſe of this, conſult the *Mechanics*, and they will ſatisfie you. There are thoſe who imagine that all Bodies that are put in Action by any means whatſoever, act with the more Power upon the Bodies they impinge, the denſer the Air is between them: For (ſay they) it is certain that the Air is condenſed in Proportion to the Velocity of the deſcending or acting Body; and all ſuch as move in a Circle (I ſpeak of this circular Motion only) have their Motion the more ſwift, the farther they are removed from their Center of Motion; ſo that the Velocities of Bodies in this caſe, are to one another reſpectively, as the *Radii* of the Circles, and the Circumferences they deſcribe. If now you take the Handle of a *Mallet* that is ſomewhat long for the *Radius* of a Circle, the Center of which is ſuppoſed to be in the Arm of him that ſtrikes; "This *Mallet* will move more freely, and with greater Ve- "locity and Power, than another *Mallet*, whoſe Handle is ſhorter though "its Weight may exceed that of the Firſt; but is ſlow and lazy in its "Action by reaſon of the Shortneſs of its Handle." Theſe Arguments are fine and plauſible: But for my part I cannot help thinking, that this may with much more reaſon be attributed to the *Conſtruction* of the *acting Body* or *Mallet*, than to any other Accident; and I cannot perſuade myſelf that the Denſity of the Air can any way contribute towards the Celerity of the *Mallet*, or make it fall the heavier upon the *Driver*; and my Reaſon is, becauſe there can be but little Air in the Space taken up by the *Mallet* in its circular Motion: Add to which, that by a frequent Repetition of that Motion the Air interpoſed between the Active and Paſſive Body would

would be rarified and diſperſed, inſtead of being condenſed, and communicating an Increaſe to the Itenſity of the Power of the Acting Body. But we ſhall in another place have occaſion to trace out more particularly the Cauſes of the Rarifaction and Condenſation of Air, where we ſhall examine in what degree the Air interpoſed between two Bodies (namely, between one fixed, and another moving naturally, or by any Force impreſſed) can either aſſiſt or deſtroy the Motion. I ſhall here remind you of what I ſaid above (*viz.*) that the Force of an Arm that acts with Violence, greatly increaſes the Velocity of the *Mallet*, and conſequently makes it fall the heavier upon any Object.

As to great *Rockets* you may conveniently drive them, if inſtead of a *Mallet*, you uſe a kind of *Beetle*, not much unlike what *Architects* and *Workmen* commonly drive down *Piles*, *Paliſades* and *Stakes* with, provided you take care to have it of a moderate Weight. This *Engine* is compoſed of 3 *Spars* or *Poles* well faſtened together at Top with a *Rope*, and ſpreads out in 3 Legs at the Bottom; and has two perpendicular Timbers, between which the *Ram* (as ſome call it) with its Iron Rings, and Head armed with the ſame Metal, is hoiſed up by means of a Rope reaved through a Pully at Top, and being up, it falls down again by its own Weight upon the *Driver*; which by this Blow violently compreſſes, and conſolidates the Compoſition in the *Rocket-Caſe*. If this *Beetle* does not exceed 100 ℔, it may be eaſily kept going by two Men, and the longer the *Spars* are the higher will it be raiſed; and conſequently falling through a greater Space in its Deſcent, the more will its Power be increaſed, according to that common Saying, *Gravis Caſus ab alto*. *Mar. Merſennus* in his *Hydraulics*, *Baliſtics* and *Mechanics*, treats largely of this, to whom I refer ſuch as are deſirous of being particularly inſtructed in it. Let us now return to the reſt of our *Inſtruments*.

Fig. 41. In *Fig.* 41 you have an Iron Cylinder terminating in a Point (or rather † *Punch)* towards the plane Superficies at Bottom, with which we pierce certain round Pieces of Paſteboard or ſtrong Paper which are put

Fig. 42. upon the Compoſition after the *Rocket* is driven. *Fig.* 42 repreſents an Iron Cone that goes tapering to a very ſharp Point, which may ſerve for the ſame Uſe as the former *Inſtrument:* In A you have a circular piece of Iron or Wood perforated in the Middle, which may be ſtopped with a ſmall Nail or little Iron Pin, running into thoſe Holes which you ſee all down the Cone with deſign to prevent the aforeſaid Piece of perforated Wood or *Ring* from ſlipping. The Diameter of this *Ring* ſhall be ſuch as may exactly fit the Orifice of a *Rocket* whilſt the Point perforates C. This may ſerve for ſeveral *Rockets*, provided it be long enough, and that you have Iron *Rings* of ſeveral Sizes, adapted to the

Fig. 43. Orifices of them. *Fig.* 43 ſhews you the Form of a piece of Wood or

† He muſt here certainly mean a *Punch*; for it is certain that a *Punch* is fitter for the Work he mentions than a *Point*.

Cap,

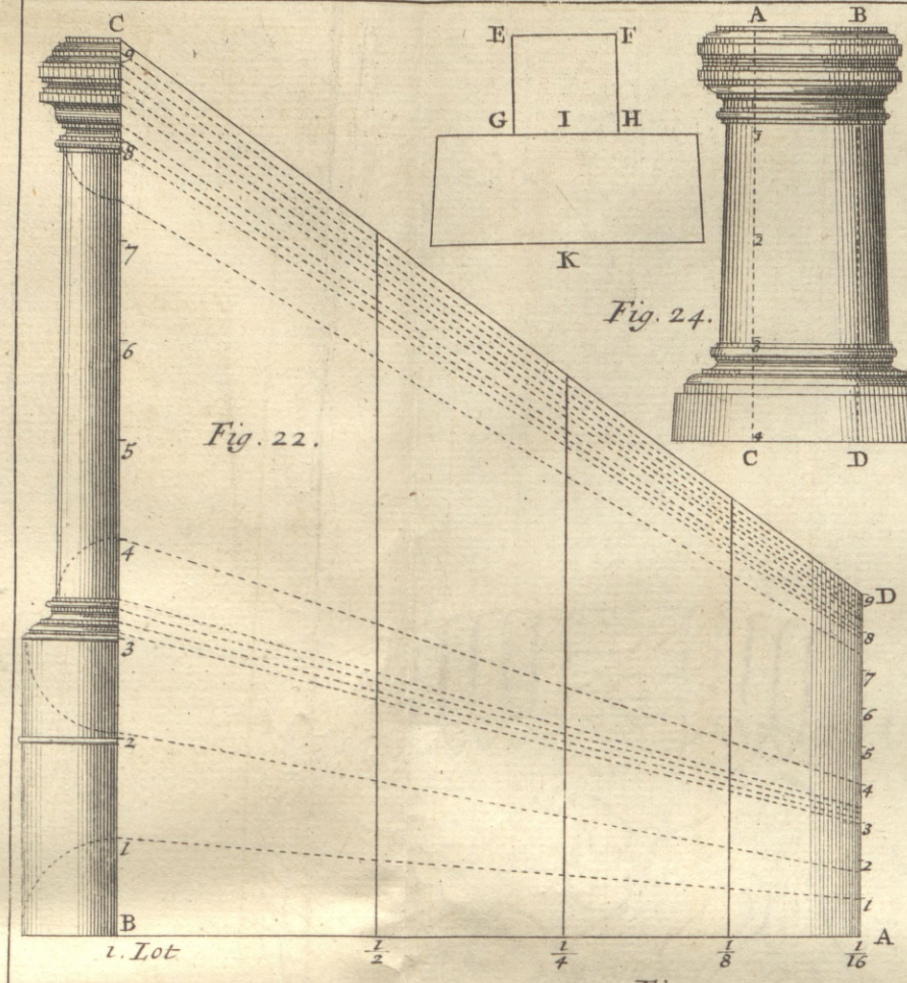


Fig. 22.

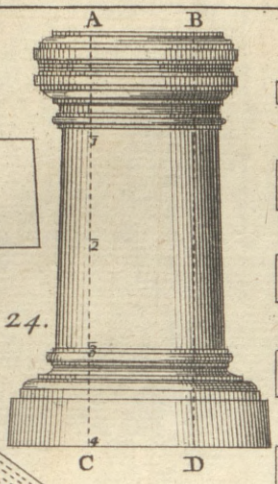


Fig. 24.

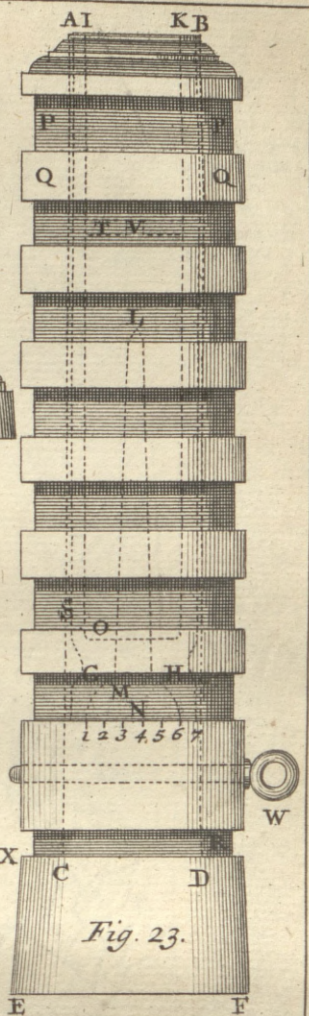


Fig. 23.

Fig. 26.

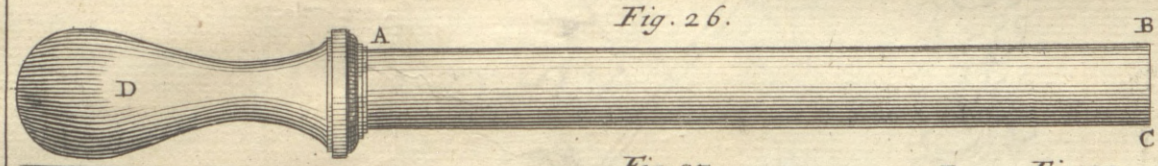


Fig. 27.

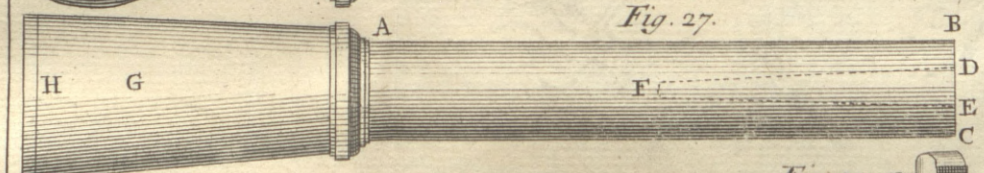


Fig. 39.

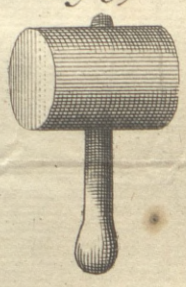


Fig. 31.

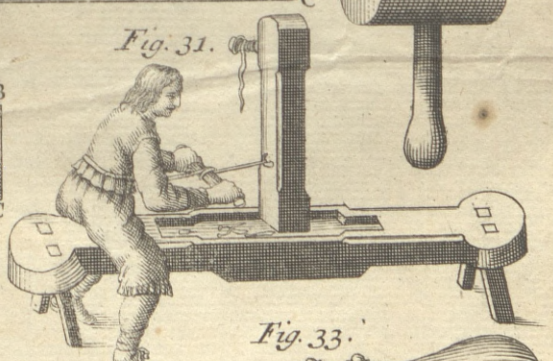


Fig. 33.

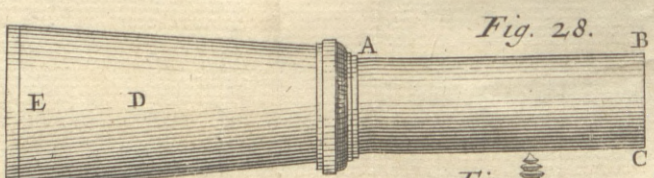


Fig. 28.

Fig. 30.

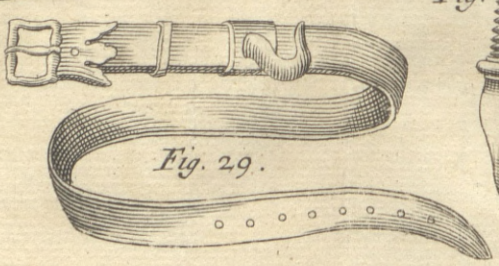


Fig. 29.

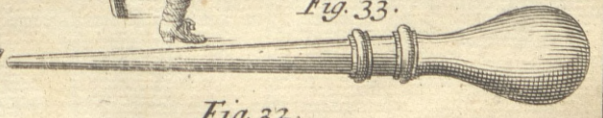


Fig. 32.

E

P.F. sculp.

Cap, to cover the ſolid *Head* of the Compoſition in great *Rockets*, which is perforated in ſeveral Places, and has its Curve Surface hollowed in a Groove like the Sheave or Shiver of a Block or Pully, the uſe of which you ſhall know hereafter. *Fig.* 44 repreſents the *Pyro-technic Knife*. In ſhort, in *Fig.* 45 you ſee ſeveral Tools diſtinguiſhed by A B and C, for cutting, hollowing, and ingraving all the Wood-work uſed in the Conſtruction of *Pyrobolical* Machines, a great Number of which I ſhall give you in the following *Books*. Fig. 44. Fig. 45.

CHAP. IV.

How to mix the Ingredients, *and prepare* Compoſitions *for all Sorts of* Rockets.

OUR *Pyroboliſts* may be very juſtly compared with the canting *Alchymiſts* of the Times paſt, (or the Preſent, if any are yet remaining) who, tho' they dealed in nothing but Smoke, yet arrogantly took upon them to be *Profeſſors* of ſo noble and excellent an Art as *Chymiſtry*; and ſweating Night and Day in ſearch of the *Philoſopher's Stone*, and other ſuch Whims as ſubſiſted no where but in their crazy *Imaginations*, to the fruitleſs Expenſe of their own Wealth or that of others; impoſed their Fallacies on the *Weak* and *Unthinking* for Truths and Things of real Exiſtence; like thoſe *Jugglers* who throw Duſt into our Eyes, to hinder us from ſeeing through their *Tricks*; and who like them are, at the End of the Chapter, obliged to feed on *Coal*, *Aſhes*, and the *Dregs* of their *Alembics*, and to drink the *Tears* forced from their Eyes by a perpetual *Smoke* as an agreeable *Ambroſia*. For even as thoſe ſooty *Adepts* carefully wrapped up the *Arcana* of their *Art*, or rather of their deceitful *Artifices*, which they upon occaſion knew how to divulge with ſuch ſpecious Appearances of *Truth*, and of which if by chance they left any Account in writing, they neither expreſſed it in *Arabick*, *Chaldean* or *Syrian* Characters, but as a Science of *Diabolical* Extraction, and (if I may ſo expreſs myſelf) immediately derived from *Hell* itſelf; and all with a Deſign to give their Profeſſion the greater Weight with the *Vulgar*; knowing well that ſuch *Things* as appear the moſt myſterious to them, and fall the leaſt under their Apprehenſion, excite their *Admiration* the moſt, and immediately beget in them a longing *Deſire* to be let into the *Secret*: Juſt ſo is it with our *Pyroboliſts*, or at leaſt with the greateſt part of them, who ſeem to have contracted this evil Cuſtom, and to have borrowed the *Alchymiſt*'s ridiculous Politics: And accordingly they would have us believe, that they obtained the Secrets of their *Art*, with much difficulty from their Maſters, or other Perſons deeply verſed in *it*: That theſe *rare Things* were communi-

cated to them in Pledge of perfect Friendſhip, or in Recompence for great Services done, or in return for ſecret Bribes of Money. But mark here their great Diſingenuity, and Malice of Heart! for leſt any one ſhould eaſily come at a Knowledge of thoſe *Secrets* which they ſo carefully conceal, or gather any thing from their confuſed *Memorandums*, they commonly expreſs every thing uſed in *Pyroboly*, together with the Weights and Meaſures, by ſuch uncouth Characters as are not to be underſtood by any but themſelves. There are thoſe, who have made certain explanatory Notes in unknown Characters to ſuch Books as they had before printed, which if they ſhould happen to be loſt, *Farewel Science!* we have nothing more to do than to ſhut up our Books and our Shops too, and believe that we have loſt the *Means* of enriching the *Pyrotechnic* Treaſures, which had been locked up in thoſe ineſtimable Cabinets. In truth, I ſhould not diſapprove of their Deſign, but ſhould commend their extreme Diligence even in this Caſe, if they would purſue the Methods marked out by others, in their Endeavours to exalt their *Art* to the higheſt degree of Perfection: But it is a very great Weakneſs and Folly in a neceſſitous Man to be aſhamed of borrowing from a Friend, what he hopes to repay very ſoon with Intereſt. It is a Task too tedious, and unequal to our Strength, to acquire an *univerſal Knowledge* by our own Induſtry, without the Aſſiſtance of others. But they are ſo far from being communicative that they do their utmoſt to hide what they have learned as holy and ſecret *Myſteries*; fondly thinking, that if they were to be divulged the Veneration they are had in would be diminiſhed by the half, and that conſequently the Profeſſors of the *Art* themſelves would loſe a great ſhare of the good Opinion the World had conceived of their Abilities. Indeed, I for my part have often ſeen great and mighty Collections of *Secrets*, *Remarks* and *Annotations*, (great and voluminous as to Paper, but ſmall and thin with regard to Science) and upon Tryal have found that all thoſe *rare Things*, which appeared ſo extraordinary to the Reader, were nothing but mere Smoke, the *Effluvia* of diſtemper'd Brains, or like Bladders ſwelled out with Wind, which can preſerve their Bulk no longer than they remain unhandled and cloſed up. Since their Humour is of this odd Turn, I ſhould think they woud act more prudently, if they would try thoſe Things they receive from others as valuable, and endeavour with all their Art to put them in Practice, before they inſert them in their public Works, by doing which they would no longer deceive others, nor be deceived themſelves. But the great Misfortune of theſe Men is their having a Notion, that all ſolid Learning conſiſts in a vaſt Heap and Multiplicity of Articles and Inventions, which they collect together where-ever they find them, without knowing whether they be *Good* or *Bad*, *Valuable* or *not*; but every thing ſhares in their Eſteem that does but contribute to ſwell up their Works. But to have done with this Topic; I think thoſe take the moſt prudent and commendable Method in their *Pyroboly*, who

make

make uſe of but one or two *Compoſitions* only which they know to be good, whether they be of their own Invention, or whether they be received from any other, whoſe Purſe is better able to go through thoſe expenſive Experiments, provided always, that they are founded upon Reaſon, and Geometrical Demonſtration. Now it being my Deſign to treat of the neceſſary *Compoſitions* for all ſorts of *Rockets* in this Chapter; I ſhall endeavour to ſhew (being certain that no one ever attempted it before) by what means, and in what Proportion the *Ingredients* ought to be mixed for the *Compoſitions* of all *Rockets*; to the end that from the fine Harmony of their Aſſemblage, and what elſe you will find in the Sequel of this Work, you may reap the Fruit and Benefit of our great Labour.

We find ſo vaſt a Number of *Compoſitions* amongſt the Profeſſors of this *Art*, that it is as much as we can do, to gueſs which are the beſt of them; for if we were to try them all, it would take up a great deal of Time and Money. Upon this Account it is that I have given myſelf the trouble for many Years paſt of ſeeking after a Method, by which I might readily come at a Knowledge of the Goodneſs of any *Compoſition*; and have been ſo nice in my Reſearch, as to put none in Practice till I had examined them by an exact Arithmetical Calculation, Geometrical Demonſtration, and by ſolid Arguments drawn from *Natural Philoſophy*. It is here then *(Candid Reader)* that I not only give you leave; but if you are a good *Pyroboliſt*, or if you have never ſo little a ſmattering of the Mathematical *Elements* joined to a little Knowledge in *Phyſics*; I do even entreat you to examine all the *Compoſitions* which I am here going to offer you, thoroughly and to the bottom: For I am pretty well aſſured that you will find nothing to diſapprove of in either my *Theory* or *Practice*. But *Firſt* you ought to know the following general Rules, which will ſerve as a Touchſtone to try the Value of all *Compoſitions*, whether they be of your own Invention, or communicated by others; and by means of which alſo you may contrive new ones at pleaſure.

The firſt Rule is: *Rocketæ quo majores fuerint, lentiori onerentur materia: quo autem minores fortiori.* That is; the larger *Rockets* are, the weaker and ſlower ſhall their *Compoſition* be; and on the contrary, the leſſer they are their *Compoſition* muſt be the ſtronger and quicker. This muſt be carefully obſerved: And the reaſon is; becauſe when the Fire ſeizes upon a ſtrong *Compoſition* in a great *Rocket*, it will devour more of it in a Moment, than it could in a ſmall *Rocket* in one, two or ſeveral Minutes; for as there is a greater Cavity in large *Rockets*, the Fire has an Opportunity of preying upon a great deal of Matter at once, and accordingly conſumes a conſiderable Quantity of it in an Inſtant. It is a very difficult thing to preſcribe Laws to Fire, which is the moſt active and voracious of all the Elements, and much more to ſet determinate Bounds to its Action whilſt there remains any combuſtible Matter

for

for it to deſtroy. From hence it will neceſſarily follow, that a ſtrong *Compoſition* producing a ſudden and inſtantaneous Combuſtion, it muſt, when in great *Rockets*, burſt them ſomewhere or other. Now this happens from the too great Concourſe and Denſity, or to expreſs myſelf clearer, from the extreme Confluence and cloſe Union of the Rays of Fire iſſuing from the Sides of the hollow Cone, which together with the great quantity of † *windy Exhalation* (generated by the Accenſion of the *Saltpeter*;) being too much ſtraitned, and requiring more room, they by their Impatience of Confinement forcibly break through the Paſteboard or Wooden Walls of their Priſon. But the Caſe is quite different in ſmall *Rockets*; for the Fire conſuming the ſtrong *Compoſition* in them by ſlow Degrees only, the Rays of *Fire* iſſuing from the Sides of their hollow Cones are fewer in Number, and in ſo narrow a place they have not ſo much *Wind* or *Exhalation* to rarifie at a Time, and therefore are in no danger of burſting.

The Second is: *Ad majores Rochetas quæ unam libram, vel duas ad ſummum ſuperant; non alligetur aliis materiis pulvis Pyrius.* For great *Rockets* that exeed 1 or 2 ℔ at moſt, you ſhall mix no *Gun-powder* with the other Ingredients. I have no other Reaſon to give for this, than what I juſt now mentioned; for when *Gun-powder* is mealed, it muſt be beaten and pounded very much, by which means it is endowed with an extraordinary Force; for the repeated Strokes add a great deal of Heat to it, and even Fire itſelf; in ſhort, the Pounding unites the *Saltpeter* with the *Coal* and *Sulphur*, and converts them into a Subſtance that is perfectly Igneous, after having purged them of all hurtful Moiſture. Upon this Account it is, that a little *Gun-powder* has more Virtue and powerful Effect, than any quantity of *Saltpeter* that might be uſed in *Compoſitions* in different Proportions.

In ſhort, the Third is: *For great* Rockets *from* 100 ℔ *down to* 10 ℔, *you muſt firſt take ſuch a quantity of clarified or purified* Saltpeter *as ſhall be equal to the* Coal *and* Sulphur; *and then afterwards let it be in a ſimple unequal* Geometrical *Proportion of Superparticular or Superpartient: but from* 10 ℔ *down to* 1 ℔ *or* ½ ℔, *let it be firſt in a Double Proportion, then Triple, and then Quadruple, and ſo on, of the* Aliquot *Parts of an Integer. In ſhort, from one* ℔ *to the very leaſt* Rocket, *let the* Saltpeter *be taken together with the* Gun-powder *in ſeveral Degrees of Superparticular and Superpartient, as Sextuple, Septuple, Octuple, Noncuple and Decuple; or Sixfold, Sevenfold, Eightfold, Ninefold and Tenfold. The Proportion of* Coal *to* Sulphur, *ſhall be either Seſquialteral, or Double, or Triple, and ſometimes Equal.*

† This is what we mean in the ſecond Book by *Flatulent Expanſion* —— both theſe Expreſſions bear one and the ſame Signification; but this is moſt intelligible here, and *Flatulent Expanſion* is more proper in the other Place.

Obſerve here however, that you muſt increaſe and diminiſh the Quantity of *Saltpeter* with regard to the two other Ingredients, as the *Coal* is to the *Sulphur*, and reciprocally as the *Sulphur* is to the *Coal*, ſo muſt they both be to the *Saltpeter*; as if (for Example) you begin by great *Rockets*, you augment the Quantity of *Saltpeter* by degrees, and diminiſh the two other Ingredients in ſuch Proportion as not to deviate from this *Arithmetical* Progreſſion. Whenever you contrive new *Compoſitions*, I adviſe you to try them before you make them public, and put them in Practice privately, that you may avoid Miſtakes, and correct ſuch Errors as you might have fallen into.

As for *Compoſitions* that you receive from others, you may examine them, if you underſtand never ſo little of *Geometrical* Proportions, and the Uſe of them; or if you will make the Experiments according to the Rules here laid down.

Accept then favorably of theſe following *Compoſitions*, which I give you for your Amuſement at your leiſure Hours. I here deliver them to you with all the Fidelity I am capable of, from thoſe of 100 ℔ down to the leaſt *Rocket* that can be made. But by the way, I have not confined myſelf to any particular *Arithmetical* Progreſſion with regard to the Proportion of *Coal* to *Sulphur*, as I propoſed above; and indeed it is not abſolutely neceſſary: But I only give you the *Compoſitions* in the Proportion and Order, I found them in my ſeveral Experiments of this kind. However, if you take upon you the trouble of proving and reducing them to an *Arithmetical* Calculation, you will find that I have ſtrictly obſerved our Firſt general *Rule* in all my *Compoſitions*.

Compoſitions *for all Sorts of* Rockets.

From 100 to 80 and 60 ℔.

Of *Saltpeter* 30 ℔, of *Coal* 20, and of *Sulphur* 10 ℔.

In this *Compoſition* you have the *Saltpeter* equal to the two other *Ingredients*, but the *Coal* is double of the *Sulphur*. You may freely uſe this *Compoſition* for all *Rockets* that can be made from 100 to 60 ℔; for it is beſt to let their *Compoſition* be weaker than what they perhaps can bear: It being by much the ſafeſt with regard to *Powder* to err on the weak ſide, that is, by allowing rather too little than too much Strength; for the Weakneſs of a *Compoſition*, or of *Powder* either, may be eaſily remedied by adding a Portion of violent Matter: But in order to be aſſured how your *Compoſition* will prove, you may make Tryal of one *Rocket* before you drive any of the reſt; from whence you may conclude concerning what you may expect from the others.

From 50 to 40 and 30 ℔.

Of *Saltpeter* 30 ℔, of *Coal* 18 ℔, and of *Sulphur* 7 ℔.

From 20 to 18 ℔.

Of *Saltpeter* 42 ℔, of *Coal* 26 ℔, and of *Sulphur* 12 ℔.

From 15 ℔ to 12 ℔.

Of *Saltpeter* 32 ℔, of *Coal* 16 ℔, and of *Sulphur* 8 ℔.

From 10 ℔ to 9 ℔.

Of *Saltpeter* 62 ℔, of *Coal* 20 ℔, and of *Sulphur* 9 ℔.

From 9 ℔ to 8 ℔ and 6 ℔.

Of *Saltpeter* 35 ℔, of *Coal* 10 ℔, and of *Sulphur* 5 ℔.

From 5 ℔ to 4 ℔.

Of *Saltpeter* 64 ℔, of *Coal* 16 ℔, and of *Sulphur* 8 ℔.

From 3 ℔ to 2 ℔.

Of *Saltpeter* 60 ℔, of *Coal* 15 ℔, and of *Sulphur* 2 ℔.

Of one ℔.

Of *Gun-powder* 18 ℔, of *Saltpeter* 8 ℔, of *Coal* 4 ℔, and of *Sulphur* 2 ℔.

From 18 *Loths*, or 9 *Ounces*, to ½ ℔.

Of *Powder* 18 ℔, of *Saltpeter* 8 ℔, of *Coal* 4 ℔, of *Sulphur* 2 ℔.

From 12 *Loths* to 10 *Loths*.

Of *Powder* 30 Loths, of *Saltpeter* 24 Loths, of *Coal* 8 Loths, and of *Sulphur* 3 Loths.

From 6 *Loths* to 4 *Loths*.

Of *Powder* 24 Loths, of *Saltpeter* 4 Loths, of *Coal* 3 Loths, and of *Sulphur* 1 Loth.

From 2 *Loths* to one *Loth*.

Of *Powder* 30 Loths, of *Coal* 4 Loths.

From ½, ¼, ⅛ to, 1/16 of a *Loth* or half *Ounce*.

Of *Powder* 9 or 10 Loths, and of *Coal* 1 or 1 ½ Loths.

The ſmaller ſort, called with us *Serpents* or *Squibs*, may be of *Meal-Powder* only, except the Priming, which ought to be of *Corn-Powder*.

CHAP.

CHAP. V.

Of the Boring *of* Rockets, *and ſeveral* Inſtruments *proper for that* Work.

AS for the *Boring* of *Rockets*, or the means of piercing their ſolid *Compoſition* in a certain determinate Proportion as to Breadth and Height; whether it be done at the ſame time that you drive them, or after they are driven; it is an Invention which I can give you no great Hiſtorical *Account* of, nor inform you whether it be New or Old. However, I cannot but think that the ancient *Pyroboliſts* were well acquainted with an Article of ſuch Importance in the Conſtruction of *Rockets*; without which it would be impoſſible for them to fly upwards; for it is owing to this Contrivance, that the *Fire* is able to accend the *Compoſition* in ſuch a manner as to have its Rays collected to a Center, and by their united Efforts, to force up the *Rocket* and all its Furniture as long as there is any Combuſtible Matter left. But I am inclined to think, that thoſe *good Gentlemen* reſerved it in Silence as a very great Secret of their *Art*: Or elſe we may believe, that they deſignedly skipped over this Article, contenting themſelves with initiating us into ſeveral other Myſteries of this *Science* which they freely enough divulged. Now for my part, after having read over and over again all the Writings of the ancient *Pyroboliſts*, I never met with one Syllable of Inſtruction relating to the Method of *boring Rockets*. In truth, I do not much wonder at this; becauſe I know it is at this Day the Cuſtom of *Fire-Workers* (and they religiouſly obſerve it) not to reveal any Secrets concerning *Fire-works* without much Importunity; and whenever they do communicate any of them, it is to ſuch Perſons only, who make this *Science* their particular Profeſſion; or perhaps to ſuch as promiſe them *great Things*: Or they may happen in their Drink to declare all they know, together with what they know nothing of; and ſo let theſe *Arcana* fall from them amongſt the reſt of their drunken Diſcourſe; which in their ſober Intervals would have been retained within their own Breaſts. But be this as it will, certain it is, that the Profeſſors of this *Art* force a ſolemn Oath from their Diſciples, after they have gone through a proper Courſe, and that they are upon the point of diſmiſſing them; in which Oath they ſwear never to reveal what has been communicated to them to any Perſon whatever, and oblige themſelves not to make a public Profeſſion of it, nor to teach it privately to others till after a Period of three Years. In this they imitate the *Cabaliſts*, who never initiate any into their Myſteries, but ſuch as are filled with a Divine Spirit, and (as they

they ſay) ſuch as were predeſtinated from their Mother's Womb to receive the Sacred Gift of *Prophecy*, or rather of *Pſeudo-Prophecy:* Myſteries which they hold in the utmoſt Veneration, and perform with extraordinary Ceremonies, muttering I know not what between their Teeth, with expreſs Prohibition (a Superſtition puniſhable with Death) never to reveal them to any living Soul. But as for me, far from entertaining ſuch narrow Sentiments, far from being actuated by ſuch a Spirit, or expecting any Reward; I here give you *Gratis*, what I purchaſed at ſo dear a Rate: And breaking Silence to oblige my Friends, and ſerve the Public; deſpiſing all the Reproaches and *Anathema's*, which thoſe *worthy Gentlemen* the *Pyroboliſts* may thunder out againſt me; I here declare openly and plainly, *That* Rockets *ought to be bored to the Height of* $\frac{2}{3}$ *of the* Compoſition *or* Matter *wherewith they are filled*, minus *a Diameter of their hollow Cylinders.* The Breadth of the Oriſice at the Choak ſhall be $\frac{2}{3}$ of the Diameter of the Mould, and go tapering up towards a Point like a Cone, in ſuch manner that the Upper Breadth of it ſhall be $\frac{1}{6}$ of the Lower; for a Cavity of this Form will be the beſt adapted for receiving the *Fire* in ſuch a manner as to oblige the *Rocket* to take its Flight. There are two Sorts of *Inſtruments* uſed for making theſe Cavities (namely) hollow *Borers*, and certain *Needles* Fig. 46. or *Piercers* of Iron or Copper, made in faſhion of a Cone. In *Fig.* 46 you may ſee a Repreſentation of theſe, diſtinguiſhed by the Letters A B C D E. A, the firſt, is for *Rockets* of 2 ℔: Its Height, B C, is $\frac{2}{3}$ of the Height of the *Rocket minus* a Diameter of its hollow Cylinder, beginning to meaſure it from that Point where the Compoſition begins (*viz.*) at the Neck or Choak, to that Point where the Matter in the *Rocket* Fig. 48. terminates. For Example, in *Fig.* 48 the Height of the *Rocket* from P to I being divided into three equal Parts, two of them will reach to G, then from G, ſubducting N O a Diameter of the hollow Cylinder of the *Rocket*, and ſetting it off downwards towards F, you will have the proper Height of the Cavity P F or E F (*viz.*) $\frac{2}{3}$ of the Height of the Rocket *minus* a Diameter of its hollow Cylinder: And its Breadth E P will be $\frac{2}{3}$ of the Diameter M B. The Upper Breadth of the abovementioned *Borer* in C is $\frac{1}{6}$ of the Lower Breadth D E. In *Fig.* B, which is the Second, you have a *Piercer* for *Rockets* of 12 *Loths* or 6 *Ounces.* C is for thoſe of 8 *Loths* or 4 *Ounces.* D for thoſe of 6 *Loths* or 3 *Ounces*; and in ſhort, E is for thoſe of 2 *Loths* or 1 *Ounce.* Now the Proportions of theſe Laſt are the ſame with thoſe of the Firſt in Letter A. You have moreover in the firſt *Fig.* A, Diviſions expreſſing the *Pierecrs* of ſmall *Rockets* down to $\frac{1}{2}$ ℔ each diſtinguiſhed by its proper Number. Know then, that I made theſe Diviſions in a Cubical *Ratio*, by dividing the right Line B C (which is the Length for the *Borer* of a *Rocket* of 2 ℔) into Parts Cubically proportionate to it; as into Subduple, which is one ℔: Into Subquadruple, which is $\frac{1}{2}$ ℔ or 16 *Loths*, and ſo on of the reſt that are between any two of them. And tho' we might

might in this manner have given the ſeveral ſmaller *Borers* deduced in proportion from one exceeding 2 ℔, I avoided it becauſe I would not have the Upper Breadths of ſmall ones too much diſproportioned to their Lower Breadths; or elſe we muſt be obliged to diminiſh the Upper Breadth of a great *Borer*, ſo as to ſerve for *Rockets* of 1 or 2 *Loths*, but they would in that Caſe be apt to be too narrow. Therefore you will do better to have your *Borers* for ſmall *Rockets* ſeparate from the greater ſort; by doing of which you will have them all nearly in one and the ſame kind of Proportion. Your *Borers* ſhould have a little ſort of Handle, that you may the more conveniently guide them; a Repreſentation of which you have in *Fig.* F. The Letter D in *Fig.* 47 Fig. 47. ſhews you another Handle which turns the *Borer* like that of a *Wimble*. In ſhort, all the Sizes of them may be eaſily fixed in a Turner's Leathe for boring of *Rockets* expeditiouſly and nicely. But if this Way does not pleaſe you, you may uſe the little *Machine* which you ſee in *Fig.* 47. which is very conveniently contrived for this Work: You muſt firſt then have a piece of Timber in Form of a Parallelopiped, ſawed through the Middle of its Breadth; or elſe compoſed of two Semi-Parallelopipeds, each of which ſhall have one Side hollowed Lengthways, ſo as to fit and hold a *Rocket* between them, as appears in A and B. This Parallelopiped ſhall be ſhut up in the *Machine*, or (as we may call it in *Engliſh*) *Square Frame*, and preſſed cloſe together with four Wooden Screws, two on each Side, as F and E, to hold them faſt, and prevent them from ſlipping: Then taking the *Borer* C in the Handle D, you ſhall ſet the Head or End of it to your Breaſt, and turning it round with your Hand, bore your *Rockets* at pleaſure. There is another Way of doing this (namely) by driving your *Rockets* upon Iron or Copper *Piercers* with hollow *Drivers*: We have given theſe the very ſame Proportions as we have aſſigned to the *Borers*. This kind of *Piercer* ought to be faſhioned as you ſee in *Fig.* 23, where M L is its Length, and Fig. 23. G H its Breadth. I muſt own, I have allotted another Proportion to *Piercers* both as to their Upper and Lower Breadths in *Fig.* 20, where the Breadth O P is ⅓ of the Diameter C D, and the Upper Breadth at Q ⅓ of the Lower Breadth O P. This I did, becauſe I have obſerved that ſeveral *Pyroboliſts* uſe this Proportion; which I can in no wiſe diſapprove of, having never ſeen the Effects of *Rockets* driven upon ſuch ſort of *Piercers*. To this I ſhall add, that *Borings* are not always made of the ſame Bigneſs, whether as to Breadth or Height, and I will not affirm, that my Obſervations will hold good in all Caſes, particularly with regard to thoſe, who make it a Practice to drive one Size of *Rockets* with ſeveral ſorts of Compoſitions; for you muſt conſider that the ſtronger a Compoſition is, the ſtraiter and ſhallower ought the *Boring* to be, and on the contrary, that the weaker and ſlower it is, the wider and deeper muſt it be *pierced*. The Reaſon of this may be eaſily gathered from what we ſaid in the foregoing Chapter; for as a ſtrong Compoſition in-

flames ſooner than a weak one, the *Rocket* which is filled with too violent a *Mixture*, and has its Orifice too wide, would let in the *Fire* too abundantly, and inſtead of departing, would be conſumed in an inſtant; inaſmuch as the *Fire* having too much room in ſo capacious a Cavity to act in, would in a Moment poſſeſs itſelf of all the *Matter*, reduce it univerſally to a Flame, and would moſt commonly burſt the *Caſe*, or elſe after having mounted to a conſiderable Height, it would at once diſperſe and appear like a Flaſh of Lightning. Small *Rockets* are in no danger of this, becauſe of the little quantity of Compoſition they contain; but for Great *ones*, be particularly cautious to fill them with a Compoſition proportioned to their Size, and to bore them in proportion to the Compoſition they are filled with; or elſe be aſſured that your Labour and Expenſe will vaniſh in Smoke. Here then *(Friendly Reader)* is what former *Pyroboliſts* have ſo induſtriouſly and ſo long hid from us; which ungrateful and envious Contagion of *Secrecy*, has ſpread down to the Profeſſors of this *Art* in our Days, who are ſo far tainted by it, as to imagine, they ſhould greatly prejudice their Reputations and private Intereſts, if they communicated any thing they make a *Secret* of, to ſuch deſerving and curious Perſons as might have a Genius for this Science. They either do not conſider, or do not know what daily Experience teaches us; (namely) that a Thouſand extinguiſhed Lamps may be lighted at one, which will communicate a Flame to them all, without being any way impaired itſelf either by a Diminution of its Oil, or the Loſs of one ſingle Atom of its Fire. As for me, I make no ſcruple of publiſhing an ingenuous Declaration of what ought not to be concealed. I indeed foreſee, that thoſe *Triflers* (they deſerve this Appellation both on the ſcore of their Ignorance and Meanſpiritedneſs) thoſe ungenerous Souls will hate me with more than a † *Vatinian* Hatred. But that gives me no manner of Diſturbance; for I know that People of any ſhare of good Senſe will laugh at their Snarls, or take no Notice of them, particularly if they recollect that common and true Saying, *Principibus placuiſſe viris vel maxime ſat eſt.* Thoſe vulgar Wretches are but little Dogs, that bark at us, without being able to bite; and if our Labours prove acceptable to our Princes, no matter for any thing elſe.

But let us have done with this Topic, and proceed farther on in the Conſtruction of *Rockets*, and ſet our Hands in good earneſt to the Work.

† This Saying is derived from *Vatinius*, the Name of a Perſon who bore a remarkable Hatred to the famous Orator *Cicero*.

CHAP.

CHAP. VI.

Of Sky-Rockets *that mount up with their Sticks.*

SORT I.

THE *Rocket* repreſented in *Fig.* 48, which we have already ſuppoſed to be of 1 ℔, has its Height A B 7 Diameters, in like manner as is its *Mould:* But from this Height we muſt firſt retrench ½ a Diameter for the Neck L M, as the Line B D ſhews upon A B. Moreover for the Binding and the Folds of the Choak to E ¼ Diameter muſt be cut off or allowed; and in ſhort, for the Binding of the Head, you again take from this Height ½ a Diameter, as may be ſeen in K I and A C; therefore the Height of the Compoſition and *Report* will be 5 ¼ Diameters, as you ſee in E I or C R. Now divide this Height into three equal Parts in the Points S and G and fill it, with a Compoſition ſutable to its Size (as we have already cautioned you) from E to G, that is, to ⅔ of the Height E I. This done, cover it with a little Cap of Paper or Paſteboard G; or what will be much better for great *Rockets*, a round hollowed Wooden Cap, ſuch as you ſee repreſented in *Fig.* 43, which ſhall be firmly glued to the Sides of the *Rocket.* If your *Caſe* be made of Paper or Paſteboard, you ſhall with a ſtrong Cord choak or force it into the Hollow in the Curve Surface of this Wooden Cap, which Cord may remain to confine it in, as you ſee in Q. But if the *Rocket-Caſe* be made of Wood, this Cap need not have its Convex Surface hollowed, but let it be uniform and plane; allowing its Thickneſs to be ⅛ of the Diameter of the *Rocket.* You ſhall faſten it to the Inſide of the *Caſe* with little Nails or Wooden Pegs, which ſhall be driven into it from the Outſide, and then well ſecured with Glue. You muſt be particularly careful in doing this; for I have often ſeen the *Caſes* of great *Rockets* remain empty upon the Nails without riſing at all, and the Compoſition for want of being powerfully confined at Top, ſlip up through the Caſe, and conſume in the Air without performing the Effect expected. However, ſmall *Rockets* which are choaked at Top are not liable to this Accident. There muſt be an Hole made through this Cap of ¼ of the Diameter of the *Rocket*, ſeveral of which may be made, if upon this Cap you would put Running *Rockets*, or (as they are uſually called in *Engliſh*) *Squibs*, and other little Decorations, which are uſed in artificial *Fireworks*, which we ſhall ſpeak of hereafter. Over this Cap you ſhall fill the Remainder of the *Caſe* with good Corn Powder, which ſhall be preſſed down ſo gently, as no way to have its Corns defaced or broken, that they may be able to retain their Vigour. In ſhort, Fig. 48.

ſhort, it ſhall be bound up cloſe at Top, and then bored from E to F, to the Height of $\frac{3}{5}$ of the Length of the *Rocket*, *minus* a Diameter of its hollow Cylinder (*viz.*) N O; which being ſet off downwards from G towards E, gives E F, which is the Height it ought to be bored.

SORT II.

Take a *Rocket-Caſe* whoſe hollow Cylinder is equal in Diameter to a Leaden Bullet of 10 *Loths* or 5 *Ounces*; let its Height be 4 and $\frac{1}{4}$ Diameter, and filled with a ſutable Compoſition to 3 Diameters, and then bored to the Depth of two of the ſame: Cover the Compoſition with a Wooden or Paſteboard Cap, having an Hole through it of $\frac{1}{11}$ of the abovementioned Diameter, then let the Top be cloſed up firmly with a ſtrong Packthread. The Faſhion of this *Rocket* may be ſeen in *Fig.* 49, where it is diſtinguiſhed by the Letter A. This done, take another *Caſe*, the Diameter of whoſe Orifice is equal to that of a Leaden Bullet of 24 *Loths* or 12 *Ounces*, and let it be 5 Diameters of its *Mould*; this ſhall be filled with a proper Compoſition, to the Height of 1 $\frac{2}{3}$ Diameter of its Orifice, and artfully bored to 1 $\frac{1}{3}$ of the ſame Diameter, ſo that there may remain $\frac{1}{3}$ of a Diameter of ſolid Head. Cover this with a Cap as before, and upon that, Corn Powder to the Height of $\frac{3}{4}$ of a Diameter. In ſhort, over all this you ſhall put the *Rocket* you had before prepared, which ſhall be firmly paſted to the Inſide of this. You will ſee the Conſtruction of this laſt *Rocket* with the firſt in it in the ſame *Figure*, diſtinguiſhed by the Letter B. To conclude; take the *Caſe* of a Third *Rocket* of 2 ℔, whoſe Height ſhall be to its Diameter as we preſcribed in the Second Chapter of this Book, and fill it with a ſutable Compoſition to the Height of 2 $\frac{1}{11}$ Diameters; you ſhall cover this with a Wooden Cap, whoſe Thickneſs and the Diameter of the Hole through the Middle of it ſhall be $\frac{1}{3}$ of the Diameter of the *Mould*; and over that, a *Report* of Corn Powder to the Height of one Diameter of the *Rocket*. This done, take the *Rocket* B, with the firſt *Rocket* A in it, and putting it into the Hollow of this Third, glue or paſte them neatly together, and cover them all three with the Conic Head F, made either of Wood or Paper. You have the whole Order of this *Rocket* in the ſame *Figure*, diſtinguiſhed by the Letter E.

Fig. 49.

Obſerve here Firſt, that the Necks of the two firſt *Rockets* do not exceed $\frac{1}{4}$ Diameter. Secondly; that you may take three Larger or three Smaller *Rockets*, and diſpoſe of them after this manner. But you muſt take care, that your two Leſſer *ones* be ſhortened in ſuch a manner, that the Third may not loſe any of its Height; and in like manner on the contrary, that they be not ſo high as never ſo little to exceed the Third that contains them; and let them be always ſo proportioned, that the Firſt exactly fills up the Second, and the Second with the Firſt in it exactly fills up the Third. If it happens that the Necks of your

Rockets

Fig. 34.

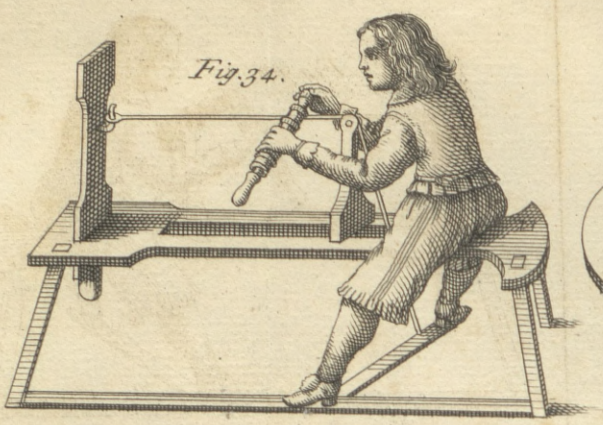


Fig. 37.

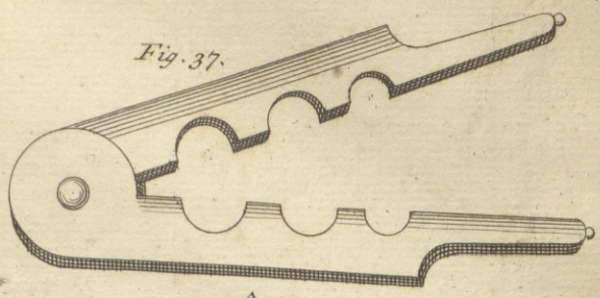


Fig. 35.

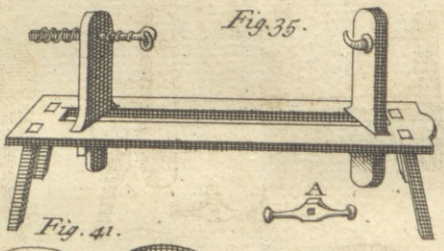


Fig. 41.

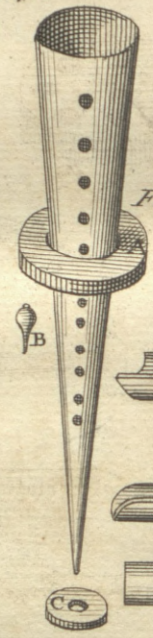


Fig. 42.

Fig. 43.

Fig. 36.

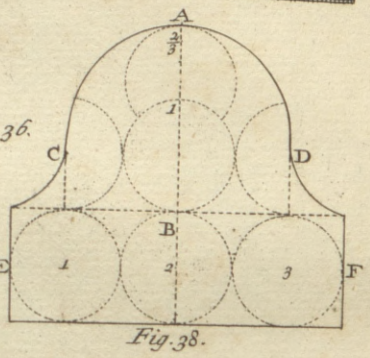


Fig. 38.

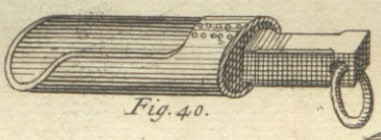


Fig. 40.

Fig. 44.

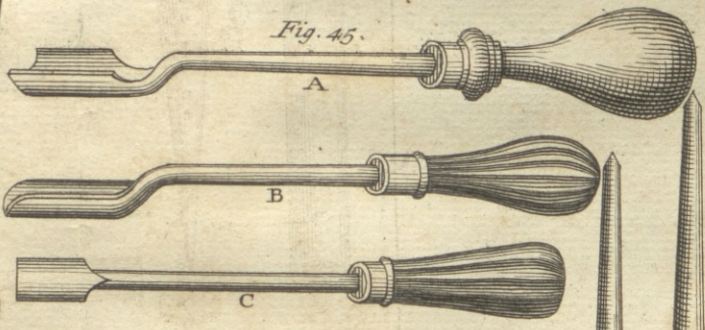


Fig. 45.

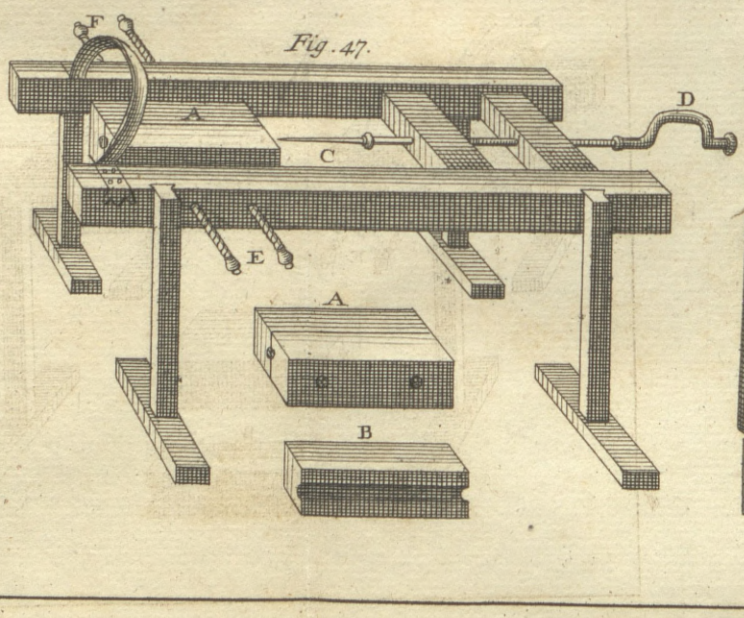


Fig. 47.

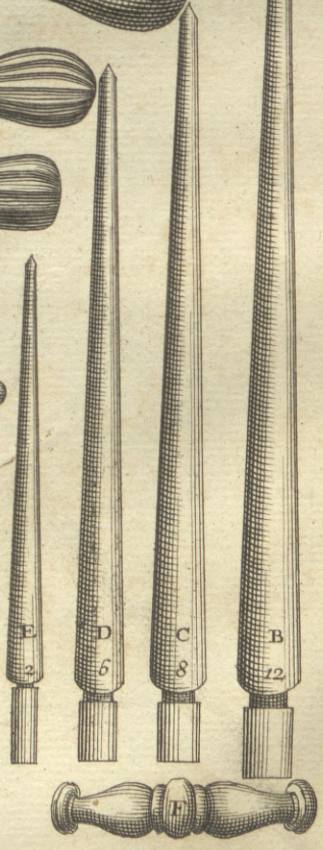


Fig. 46.

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Rockets do not nicely obſerve the Proportion I have laid down, it will be no great matter, provided that their Diameters are as they ought to be: And in this Caſe, the Third *Rocket* muſt be driven with a ſlower Compoſition than its Size requires. Thus the two Firſt will by the Third be carried up into the Air, where they perform their Parts; flying from one ſide to the other in Oblique Directions; for they cannot aſcend perpendicularly, for want of Sticks or a Counterpoiſe; but we ſhall touch upon that at the End of this Chapter.

SORT III.

Take a great *Rocket* (*viz.*) of 2, 6, 8, or if you will of 10 or 20 lb; and fill it with a Compoſition ſutable to its Size, and bore it as uſual; according to the Method directed in the firſt Sort of *Rockets*; and after having covered it with a Cap, with ſeveral Holes pierced through it as you may ſee in A, you ſhall ſalt it over with *Meal Powder*, mixed with an equal Portion of that in *Corns*. Then fill up the remaining Cavity of the *Rocket* with ſmall Running *Rockets*, or (as we call them in *Engliſh*) *Squibs*, and leave a Space in the Middle of them, for a Wooden Caſe or Tube, which you ſee repreſented in *Figure* 54, and Fig. 54. which you ſhall prepare after the following manner. Take a hollowed Cylinder or Tube of Wood, equal in Height to the Space left of the *Rocket*; or it may be continued up to the inner *Vertex* of the Cone that crowns your *Rocket*. Let the Thickneſs of the Wood a b, be $\frac{1}{4}$ of the Diameter a c; and let the Bottom f g be $\frac{2}{3}$ of the ſame Diameter, to which may be faſtened a Leaden Bullet by way of Counterpoiſe. This Tube or Caſe ſhall be filled thus: Firſt, pour in *Corn Powder* to the Height of $\frac{1}{2}$ a Diameter, and upon that a *Light Ball*, the Conſtruction of which I ſhall teach you in the Third Chapter of the next Book; over this Ball put *ſlow Compoſition*; upon this, *Corn Powder* again in the ſame Proportion as before, and upon that another *Light Ball*; then *ſlow Compoſition*; and in this Order you muſt proceed till your Caſe or Tube is filled up. We ſhall treat of *ſlow Compoſitions* hereafter; and in our Book of the ſeveral *Pyrotechnical Machines*, we will enlarge upon what relates to this ſame *Caſe*. The whole being diſpoſed after this manner, and the Tube filled as we have directed, well re-inforced with good Iron Wire, or ſtrong glued Packthread, for fear the *Powder* ſhould ſplit it, it ſhall be fixed in the Middle of the *Squibs* with its Mouth downwards upon the *Meal* and *Corn Powder* abovementioned. The whole being thus compleated, ſhall be cloſed at Top with a Wooden or Paper Head, according as the *Rocket-Caſe* is made of either the one or the other of them. You have a full and particular Repreſentation of this in *Fig.* 50. Fig. 50.

SORT IV.

This kind of *Sky-Rocket* differs but little from the foregoing, except that inſtead of ſmall *Rockets* or *Squibs* in the empty Space above the Compoſition, you put either Sparks or Stars (which we ſhall teach you to make in the Third Chapter of the following Book) interſperſed with *Meal* and *Corn Powder:* As for any thing elſe relating to it, you are to proceed in the ſame manner we did with the Firſt. See the Repreſen-
Fig. 51. tation of this in *Fig.* 51.

SORT V.

You ſhall take a *Rocket* of any Size you will, and fill it with a proper Compoſition to 2 $\frac{7}{8}$ Diameters of its Orifice or hollow Cylinder; and cover it with a Wooden Cap, whoſe Thickneſs is $\frac{1}{8}$ of the ſame Diameter; and over that, *Corn Powder* to the Height of $\frac{6}{8}$ of a Diameter; and upon that, Compoſition to $\frac{1}{8}$ of a Diameter: This muſt be covered with a Cap, and that again, with *Corn Powder* as before; and upon that, Compoſition as before, and ſo on till the *Rocket* is quite filled. This done, it ſhall be tied cloſe and firm at Top, and bored to the Depth of
Fig. 52. 2 $\frac{1}{8}$ Diameters. *Fig.* 52 ſhews you the whole Order of this.

SORT VI.

You ſhall firſt take a *Rocket*, and fill it according to the common Rule and Order, and bore it as we did the *Rocket* of the Firſt Sort. This done, prepare certain Boxes or Caſes of dry light Wood, the ſame as
Fig. 53. you ſee repreſented in *Fig.* B, under *Fig.* 53, or elſe firm Paper Caſes like thoſe of *Rockets*, choaked cloſe at Bottom. Then with hot Glue ſtick as many as you pleaſe of them, to the exterior Surface of the *Rocket* as you ſee in C, minding to place them in a Spiral Direction, and tye them faſt with good Packthread as you ſee in the Letter D. Into each of theſe Boxes put a *Running Rocket*, filled with *Meal Powder*, and opened at the Choak, through which and the Boxes, the *Fire* may be conveyed from the great *Rocket*. The great *Rocket* might ſerve for a *Petard* or *Cracker* filled with *Corn Powder*, but inſtead of that, you may uſe Iron *Crackers*, whoſe upper Part ſhall be filled with fine *Powder*, and the lower Part with *Rocket* Compoſition. The Letter A ſhews you one of the abovementioned Boxes, with the *Running Rocket* in it, to render the thing more eaſy to your Apprehenſion.

SORT VII.

Fill a *Rocket* with a reaſonable Compoſition, to the Height of 2 Diameters of its Orifice; and bore the ſaid Compoſition to the Depth of one Diameter, and to the Breadth of $\frac{1}{8}$ Diameter. Cover this Boring with a piece of Paper only, to prevent its being filled up whilſt you drive the reſt of the *Rocket*; this Order you are to obſerve till your *Rocket* is quite filled; (namely) by always putting in 2 Diameters of Compoſition and boring one. See *Fig.* 55. Fig. 55.

SORT VIII.

You muſt here obſerve the ſeveral Circumſtances relating to the Firſt, Fourth, and Sixth Sorts, as well in filling this *Rocket*, as in boring it. Suppoſe then, that you have a *Rocket* prepared as it ought to be: You ſhall ſtick round the Outſide of it, as many Paper *Crackers* as you ſhall think fit, (ſuch as you ſee diſtinguiſhed by A) and at ſuch Diſtances as you ſhall think moſt proper. Then prime both them and the *Rocket* with *Meal Powder*. *Fig.* 56 plainly illuſtrates this. Fig. 56.

SORT IX.

This Ninth Sort of *Rocket* ſhall be prepared after the following Order: You ſhall firſt fill the *Rocket* with a ſutable Compoſition to the Height of 2 $\frac{5}{8}$ Diameters; which ſhall be covered with a Wooden Cap, having an Hole through the Middle of it: And over the Cap you ſhall put a Layer of *Corn Powder* to the Height of $\frac{5}{8}$ of the Diameter of its Orifice; upon which ſhall be a Layer of *Compoſition* to the Height of $\frac{3}{8}$ of the ſame Diameter. Then taking a ſtrong Cord, choak the *Rocket* cloſe above the *Compoſition*, leaving only a ſmall Hole of Communication in the Middle of it. This done, you ſhall put in *Compoſition* afreſh to the Height of $\frac{1}{8}$, and upon the ſaid Compoſition *Corn Powder* to the Height of $\frac{5}{8}$. In ſhort, upon this *Powder* you ſhall put *Compoſition* to the ſame Height as before, and choak it again a ſecond time. In this Order you ſhall proceed till the *Rocket* is filled up. This will appear obvious to you in *Fig.* 57. Fig. 57.

SORT X.

This *Rocket* has nothing particular in it, to make it very different from the reſt; for, firſt, it is filled and bored after the ſame manner with thoſe of the Firſt, Fourth, and Sixth Sorts. There is only an Addition to it of a *Report*, and upon that, a longiſh hollow piece of Wood in a Spherical Form, fill'd with an Aquatic Compoſition, (by

Aquatic

Aquatic, I mean ſuch Compoſitions as are contrived to burn upon or in the Water, which I ſhall give you in the following Book) or any other ſtrong Mixture. You muſt fire this *Rocket* at the Head before you fire it at the Orifice of the Choak, becauſe the upper Compoſition has no Communication with the lower Part of the *Rocket*. Being then moved off, and having taken its Flight into the Air, you will ſee two Sorts of *Fire* (namely) that of the *Rocket* darting its Rays downwards, and the other iſſuing from the Head, and ſpreading abroad in the Air like a great Fire Rain. This is clearly explained to you in *Fig.* 58.

Fig. 58.

SORT XI.

Take 7 ſmall *Rockets* of 2, 3, 4, or more *Ounces*, filled with a common Compoſition, and bored as uſual: Bind them up together in a round tight Bundle, and wrap them about with ſtrong Paper or Paſteboard, and head them with a large Cone of the ſame, as you ſee in A. You muſt not forget to ſtick them (I am juſt going to inſtruct you in the Rules relating to *that*) in ſuch a manner, that the upper End of the *Stick* may come under the great Paper Caſe that encompaſſes the *Rockets*. *Fig.* 59 will fully inſtruct you as to this.

Fig. 59.

Obſerve here that the ſeveral Sorts of *Rockets* I have been now treating of, require to have *Sticks* faſtened to them, to ſerve them as a Counterpoiſe, and to aſſiſt them in their right Aſcent. They are uſually made of light dry Wood, ſuch as Pine, Fir, and Lime-Tree. Their Length muſt be to that of the *Rocket* in a Septuple, or at moſt an Octuple Proportion; that is, they are commonly 7 or 8 times as long as the *Rocket*. They ought to be of a tolerable Thickneſs at the End to which the *Rocket* is tied, and from thence down to the lower End go gradually tapering to a Point. The neceſſity there is for them, is not ſo much on the ſcore of their Figure, as on account of their extreme Equality as to Weight; or the nice *Æquilibrium* which muſt be obſerved in fitting them to the ſeveral Weights of *Rockets*. Now you will find it no great difficulty to adjuſt them exactly, if you put the *Stick* at two Finger's Breadth from the Neck of the *Rocket* upon the Edge of a Knife, or upon your Finger, and if in that Situation both Ends are in *Æquilibrio*, you are right; that is, the End to which the *Rocket* is faſtened and the other muſt be exactly parallel to the Horizon, without inclining or wavering to one Side or the other. But if your *Stick* End happens to overbalance, you muſt pare and diminiſh it till it comes to an *Æquilibrium* with the *Rocket* End. You have a *Rocket* with its *Stick* plainly and curiouſly repreſented in *Fig.* 60. *Brechtelius* teaches us a Method (which is eaſy enough) to find out the proper Length of theſe *Sticks* in Chap. IX. of the Second Part of his *Pyrotechnics*, as follows: Add one to the Number of *Fingers* that conſtitute the Length of your *Rocket*, and multiply the Product by the Length of the *Rocket*, and you will

Fig. 60.

Fig. 48.

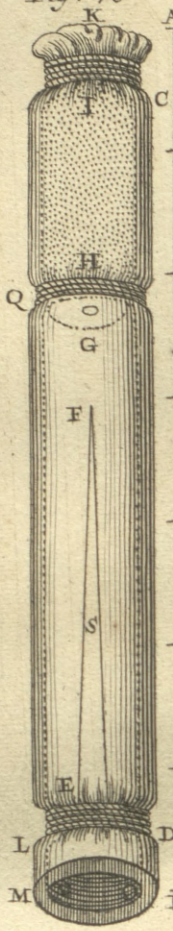


Fig. 49.

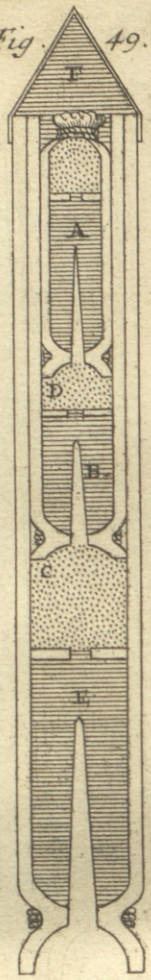


Fig. 50.

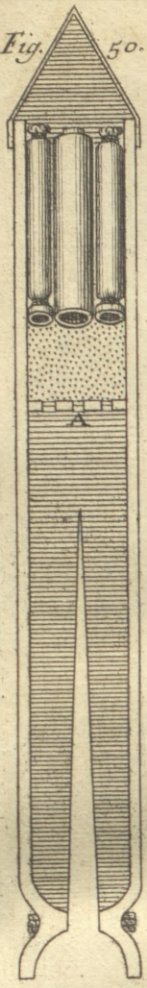


Fig. 51.

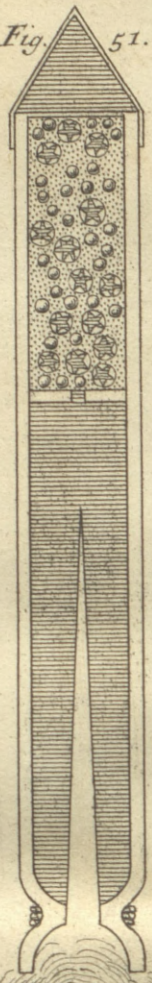


Fig. 52.

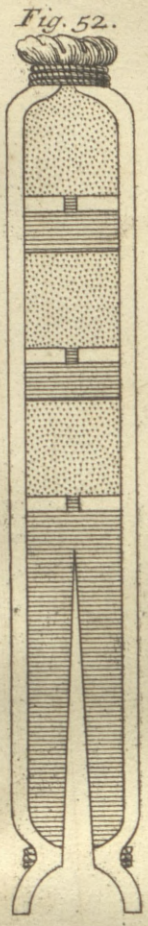


Fig. 53.

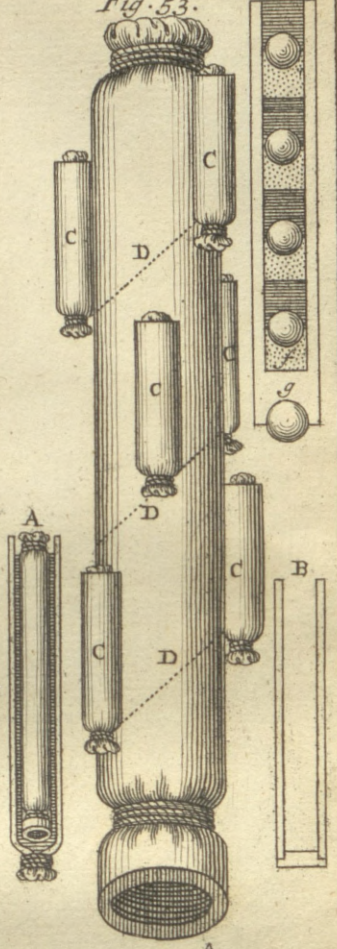


Fig. 54.

Fig. 55.

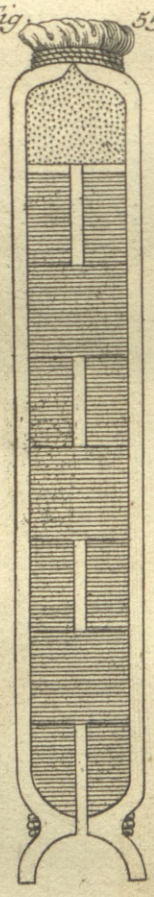


Fig. 56.

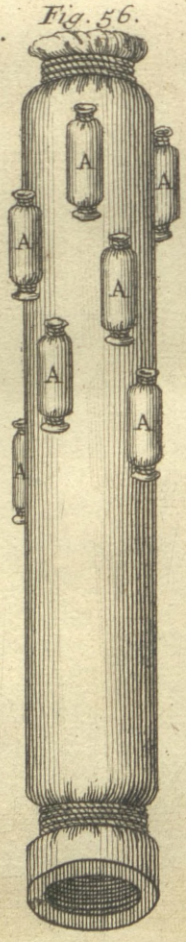


Fig. 57.

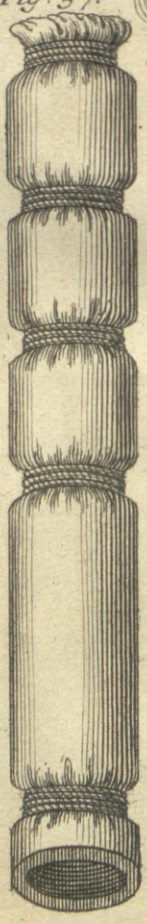
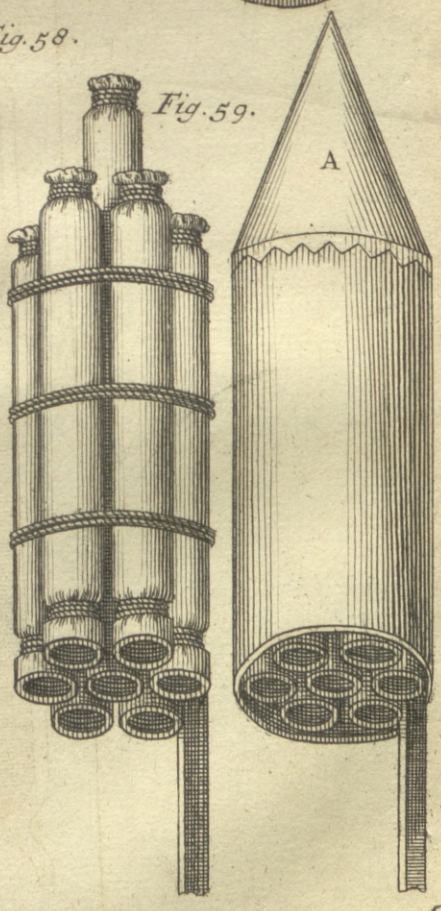


Fig. 58.

Fig. 59.



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will have the due Length of its *Stick:* For Example; if the *Rocket* is 8 *Fingers* in Length, add 1 to them, and you will have 9; which Number multiplied by 8, which is the Length or Height of the *Rocket*, will give 72. You ſhall then tye a *Stick* of ſo many *Fingers* in Length to your *Rocket*.

CHAP. VII.

Of Sky-Rockets *that mount up without* Sticks.

SORT I.

TAKE a ſmall *Rocket* of 8, 10, 16, or 18 *Loths*, filled and bored as uſual, and fix four ſmall *Wings* to it after the manner of the Feathers of an Arrow: (Letter A in *Fig.* 61 will explain what I mean.) Fig. 61. Theſe *Wings* muſt be made of light Wood, ſuch as Lime-tree, or elſe of Paſteboard, and muſt be placed croſs-wiſe. Their Length ſhall be $\frac{2}{3}$ of the Length of the *Rocket*, and their Breadth at Bottom ſhall be $\frac{1}{6}$ of the ſame Length; their Thickneſs may be left to your own Diſcretion: Nevertheleſs if you would have *it* in ſome ſort proportionable to their Length and Breadth, it ſhall be of $\frac{1}{6}$ or $\frac{1}{8}$ of the Diameter of the *Rocket*.

In *Fig.* 63 I have given you the Repreſentation of a little Contrivance Fig. 63. compoſed of 4 Rods, a Bottom, and an Handle beneath, upon which you may ſet this ſort of *Rockets* when you fire them. It needs no farther Explanation, ſince it may be readily underſtood by the *Figure* itſelf. In the Middle of the Bottom-Piece, in which the aforementioned Rods are fixed, is a little Cavity or Chamber, that has Communication with a little Channel; the which as well as the Chamber itſelf muſt be filled with *Meal Powder*, when you would fire your *Rocket*.

SORT II.

This kind of *Rocket* differs but little from the former, except that its *Wings* are otherwiſe contrived; for upon this you have but three only, of the ſame Thickneſs with the others, but pretty different from them in Height and Breadth; for the Length of theſe is equal to the whole Length of the *Rocket* to which they belong, and are fixed upon it in ſuch a manner, that the Lower Extremities of them deſcend one Diameter below the Neck of the *Rocket*, and conſequently their Upper Extremities muſt fall an equal Portion ſhort of the Head of it. Their Breadth ſhall be a Semi-Diameter of the Orifice or hollow Cylinder of the *Rocket*, as you may ſee by a, b. You may, if you pleaſe, fire this

kind of *Rockets* upon the Contrivance above deſcribed, in order to make
Fig. 62. them fly up with the greater Conveniency. See *Fig.* 62.

SORT III.

Having made a *Rocket* of what Size you pleaſe according to the ordinary Method, you ſhall to the Neck of it faſten a piece of Iron Wyre, with an Iron Bullet at the End of it, of the ſame Calibre with the *Rocket:* This Wyre ſhall be turned in a Spiral like a Screw, and ſhall be as near as poſſible of ſuch a Length, that in caſe it happens to widen or ſtretch a little, the Bullet may notwithſtanding be in *Æquilibrio* with the *Rocket*, in the ſame manner as we juſt now ſaid of *Wooden*
Fig. 64. *Sticks*. *Fig.* 64 will give you a perfect Idea of this.

SORT IV.

After you have prepared a *Rocket* as you have been fully directed, and that you have covered the *Compoſition* in it with *Corn Powder* to the Height of one Diameter, fill up the remaining Vacancy with Raſpings or Filings of Lead; obſerving that the Quantity of it be ſuch, as to be
Fig. 65. twice the Weight of the *Rocket-Caſe* it belongs to. Conſult *Fig.* 65, which will ſet you right.

CHAP. VIII.

Of Water-Rockets, *or ſuch as* Burn *and* Swim *upon the* Water.

SORT I.

YOU ſhall fill a *Rocket* of 2 or 3 *Loths* with a ſutable *Compoſition*, to the Height that we uſually fill common *Rockets*; and fixing a Cap upon the *Compoſition* with a *Report* of *Corn Powder* above it, it ſhall be bored throughout the whole Height of the *Compoſition*. This done, prepare a Paper Cylinder, with two ſmall Wooden or Paſteboard Heads or Baſes, having a Hole bored through the Center of each. The Height of this Cylinder ſhall be equal to but half of the *Rocket*, and the Hole through the Center of each Head ſhall be made to fit the *Rocket* exactly. In ſhort, being nicely fitted, and thruſt through the Hole in the Center of each Head of the Cylinder, throw *it* into a quantity of melted Wax or Pitch; after which the *Rocket* may be fired,
Fig. 66. and thrown into the *Water*. See *Fig.* 66.

SORT S

Sorts II, and III.

These Sorts differ very little from the foregoing, whether in Size, or the manner of filling and boring them, or any thing else relating to their Construction. And the only difference between these two, is, that the First *(viz. Fig.* 67*)* ought to be shut up to the Neck in a Paper Cone, whose *Vertex*, (as you see in the *Figure)* or *Base*, no matter which, is made fast to the Neck of the *Rocket*. The Second *(viz.) Fig.* 68 is put into a Bladder full of Wind; which must not be dipped in melted Wax or Pitch like other *Water-Rockets*, but only dawbed over with a Liniment, made of *four* Parts of Linseed Oil, *two* Parts of Bole Armoniac, *one* Part of *Plume* Allum, and *half* a Part of Ashes. Fig. 67. Fig. 68.

Sort IV.

The *Rocket* which you see represented in *Fig.* 69, must be prepared after the same manner we ordered with regard to the Ninth Sort of *Sky-Rockets* in Chap. VI. of this Book, excepting that it must not be bored, and that the Orifice of its Choak is very small, which it has in common with other *Water-Rockets*; this is not designed to move upon the Surface of Water, but to burn in one particular Place; and for this Reason there is a Weight tied to the Bottom of it at A. This also must be plunged in melted Wax or Pitch, as well as all the following. Fig. 69.

Sort V.

Fig. 70 represents a *Rocket* which is prepared after the same manner with the Third Sort of *Sky-Rocket* in Chap. VI, only with this difference, that its *Composition* is separated by a solid Cap G from certain Sparks and Stars intermixed with *Meal* and *Corn Powder*. To this also belongs a little Iron or Wooden Tube distinguished by B: And from each End of this Tube, there goes another smaller Tube (*viz.*) C D and F E; all three of which have a Communication with one another, and likewise with the *Composition*, and the *Stars*, *&c.* aforesaid. The Fire, as soon as ever the *Composition* is burn'd down to the Cap, is conveyed through the aforementioned Tubes to the Head of the *Rocket*, where accending the *Meal* and *Corn Powder*, the *Stars*, (and whatever else might have been in it,) are blown up into the Air. Its Counterpoise may also be seen in Letter A. Fig. 70.

Sort VI.

In *Fig.* 71 you have a *Rocket* that is perfectly like the Sixth Sort of *Sky-Rockets* which we described in Chap. VI; for here the great Boxes Fig. 71.

or

or Caſes diſtinguiſhed by E, and the *Rockets* contained in them by B; and the others of ſmaller Size, pointed out by D, and the leſſer *Rockets* in them by C; ſtick alſo to the great *Rocket* A; which communicates *Fire* through the little Tubes H, into the Boxes on each Side of it; which enkindling the *Powder* under the *Rockets* contained in them, blows them up into the Air to perform their Parts. This kind of *Rocket*, together with the *Boxes* or *Caſes* on each Side of it, muſt be wrapped about with ſtrong Paper, as may be ſeen in G, and then thrown into melted Wax: Nor muſt you forget to add a Counterpoiſe under it, that it may burn upright, and float at nearly an equal Height above the *Water*.

SORT VII.

Fig. 72. The *Rocket* which you have in *Fig.* 72, has nothing farther in the Preparation of it, than what I directed with regard to the Fourth Sort of *Rockets* in the foregoing Chapter; and all the difference between them, is, that this is not to be bored, as I have already obſerved; beſides its being coated with Wax or Pitch, and burning in the *Water*.

CHAP. IX.

Of Rockets *that run upon* Lines *or* Ropes.

SORT I.

TYE two Iron Rings or a Wooden Tube to a *Rocket* filled with a certain quantity of *Ounces* of a ſutable *Compoſition*, and bored as it ought to be: Then reave through the Rings, or Tube, the *Line* which you would have your *Rocket* to run upon. This is of the moſt ſimple kind; for being arrived at the Place, which the Duration of its combuſtible Matter will allow it to reach, it there ſtops. The following will be much more artificial. You have a Repreſentation of this in

Fig. 73. *Fig.* 73.

SORT II.

Fill any particular *Rocket*, whoſe Orifice may be equal to that of the foregoing (but much longer) to the Height of 4 Diameters, and bore it to the Depth of 3 ½. Then upon this *Compoſition* put a Cap or a little Wooden Partition which muſt have no Hole through it, and may be glued to the Inſide of the *Rocket*, or any other way well ſecured, to prevent the *Fire*, when it is arrived at that Length, from catching hold of the *Compoſition* contained in the other Part of the Caſe. This done,

you

you muſt charge the Remainder of the *Rocket* to the ſame Height as before; namely to 4 Diameters; 3 ½ of which muſt be bored. You muſt then choak the *Rocket* at Top, and make a little Receptacle for the Priming as at the other End; or elſe fit a round piece of Wood to it with an Hole through the Middle of it, as may be ſeen in A, which muſt be covered with a little Cap, as you will ſee diſtinguiſhed by the ſame Letter. To this you muſt add on one Side a Tube made of a very thin Iron Plate, which muſt be filled with *Meal Powder*. Bore an Hole through the Side of the *Rocket* near the Partition in the Middle, and fill it with *Meal Powder*; which is done, the more readily to convey the *Fire* through the Tube, to the other Receptacle where it lights the *Rocket* at the other End, and conſequently obliges it to return back to the Place from whence it came. The upper Part which holds the Priming muſt be covered with Paper, as well as the ſmall Tube that conveys the *Fire* from one End of the *Rocket* to the other. This ſhall alſo have a Wooden Tube, or two little Iron Rings to run upon along the *Line*. You will have the more Diverſion if you tye ſmall Paper *Crackers* all round it. The Contrivance of this *Rocket* is very pretty. You have a Repreſentation of it in *Fig.* 74. Fig. 74.

SORTS III and IV.

Take two *Rockets* of equal Length, conſtructed according to the Method we have already laid down, and let them be bound together with ſtrong Packthread, and let the Head of the one be even with the Choak of the other, and ſo on alternately, to the end that the Firſt of them being burned out to the very End, it may catch hold of the other, and oblige them both to return back again. The extremity by which you intend the firſt ſhall fire the other, (that is the Neck of the one and the Head of the other) ſhall be capped with Paper, or any thing elſe, as you ſee in *Fig.* A, minding to fill the Vacancy of the Cap with *ſlow Compoſition*. In ſhort, you muſt add a Tube to them, to run upon. See them repreſented by *Fig.* 75 and 76, by which you will obſerve a difference between them; the latter having a piece of Wood hollowed on each Side to receive them both, and keep them at a little diſtance from one another, in Conſideration that if by chance the Firſt ſhould burſt, the other may receive no damage from it. Fig. 75. and 76.

Obſerve here that theſe *Rockets* commonly ſerve to fire ſeveral *Pyrobolical Machines* which are uſed upon Rejoicing Occaſions. Sometimes alſo they are diſguiſed under the Form of divers Animals, whether Fictitious or Real, ſuch as, Flying Dragons, Doves, and other things which you would contrive to vault and run up and down, which we ſhall treat of in our Book of *Pyrobolical Machinery*.

In *Fig.* 77, 78 and 79, you have three Contrivances for hanging up *Sky-Rockets* when they are to be fired. Fig. 77, 78, 79.

CHAP. X.

Of the ſeveral Defects *of* Rockets. *How to avoid them: Together with what ought be obſerved in the right* Conſtruction *of them.*

THE *Firſt* and moſt remarkable Vice in *Rockets*, is, when after being fired, and mounted to the Height of 2 or 3 *Perches*, they break and diſperſe without performing their proper Effects.

The *Second*, which is not much better than the Firſt, is when they remain ſuſpended upon the Nails, waſting ſlowly away without moving off or riſing at all.

The *Third* is, when in their Aſcent they form an Arch, or deſcribing a Semi-Circle, return down again to the Ground before all their *Compoſition* is burn'd out.

The *Fourth* is, when they mount in a Spiral Line, winding up into the Air, without obſerving an uniform, regular and right Motion as they ought.

The *Fifth* is, when they move up heavily and lazily, as if they refuſed or ſcorned to take their Flight.

The *Sixth* is, when the Caſes hang empty upon the Nails, and the *Compoſition* riſes and diſperſes in the Air.

There is ſtill a greater Number of vexatious Accidents, which may fruſtrate the Hopes, the Labour, and the Expence of the *Pyroboliſt*; and which would be too tedious for me here to enumerate. It will be ſufficient if you keep an Eye upon theſe, which are the moſt to be feared and provided againſt; and in order to avoid and rectifie them, pleaſe to obſerve the following *Rules*.

Infallible Rules *for the conſtructing of* Rockets, *without any Defect.*

1. Your *Rockets* ſhall have their Heights proportioned to their Orifices or hollow Cylinders, after the manner we have ſo often repeated.

2. Whether your *Caſes* be made of Paper, or Wood, they ſhall be neither too thick nor too thin.

3. They ſhall be made of Paper which is moderately dry, neatly rowled, and perfectly tight to the *Rowler*.

4. Their

4. Their Necks ſhall be well and firmly choaked; ſo that neither the Knots of the Cord or Packthread, nor the Folds of the Choak, may dilate or give way; and therefore they ſhall be reinforced with Glue.

5. All the *Ingredients* that enter into the *Compoſition*, being exactly weighed in Proportion to the Orifice or Size of the *Rocket* you intend to make; ſhall be firſt mealed and paſſed through a Searce ſeperately: Then weighing them again, they ſhall be well incorporated together in one Maſs, and mealed a ſecond time, and paſſed through a fine Searce as before.

6. The *Saltpeter* and *Sulphur* ſhall be purified and mealed as fine as poſſible: The *Coal* ſhall be perfectly well burn'd free from Moiſture, and made of ſome light ſoft Wood, ſuch as Lime-Tree, Hazel, and Branches of Willow: And on the contrary be cautious not to make it of Birch, Oak, Maple and Service-Tree; becauſe they are naturally impregnated with a great deal of groſs Earthy Matter.

7. Your *Compoſition* ſhall be prepared juſt before you want it.

8. It ſhall be neither too moiſt nor too dry; but ſprinkled over with a little of ſome Oily Humour, or a little Brandy.

9. When you drive your *Rockets*, be always mindful to put equal Quantities of *Compoſition* into your *Caſes* at a time.

10. The Strokes of your *Mallet* ſhall fall in a perpendicular Direction upon the *Driver*.

11. Your *Rockets* muſt be driven with *Mallets* of proportionable Weight to their Size; with an uniform Succeſſion, and an equal Number of Strokes every time you pour any *Compoſition* into the *Caſes*.

12. In Paper *Caſes* you ſhall cover your *Compoſition* with Wooden Caps, with an hollow Convex or Curve Surface; but for Wooden *Caſes* their Convexity ſhall be plain, that they may be the more firmly ſecured in the *Rocket*.

13. Your *Rockets* ſhall be bored with a ſutable *Borer*, or *Taper-bit*, ſo that their hollow Cones may be neither too Wide, nor too Narrow, too Long, nor too Short.

14. The Cavity or hollow Cone ſhall be as Upright and Perpendicular as poſſible, and exactly in the Middle of the *Compoſition*; ſo as not in the leaſt to lean to the one Side or the other.

15. You ſhall not bore your *Rockets* till juſt before you uſe them, and when they are bored they ſhall be tenderly handled, with the ends of your Fingers only, for fear of diſordering their Form.

16. Their *Sticks* or *Rods* ſhall be nicely proportioned to them, both as to Length and Weight, according to the Rule and Method above given. They ſhall neither be bent nor crooked, uneven nor knotty; but as ſtrait and as ſmooth as poſſible; and if need be, they may be planed.

17. Your *Rockets* being filled and compleated, take care how you put them into too dry or too damp a Place; for both the one and the other may ſpoil them; therefore chuſe ſome temperate Place.

18. When

18. When you would fire them, they muſt be ſuſpended upon Nails, perpendicular to the Horizon.

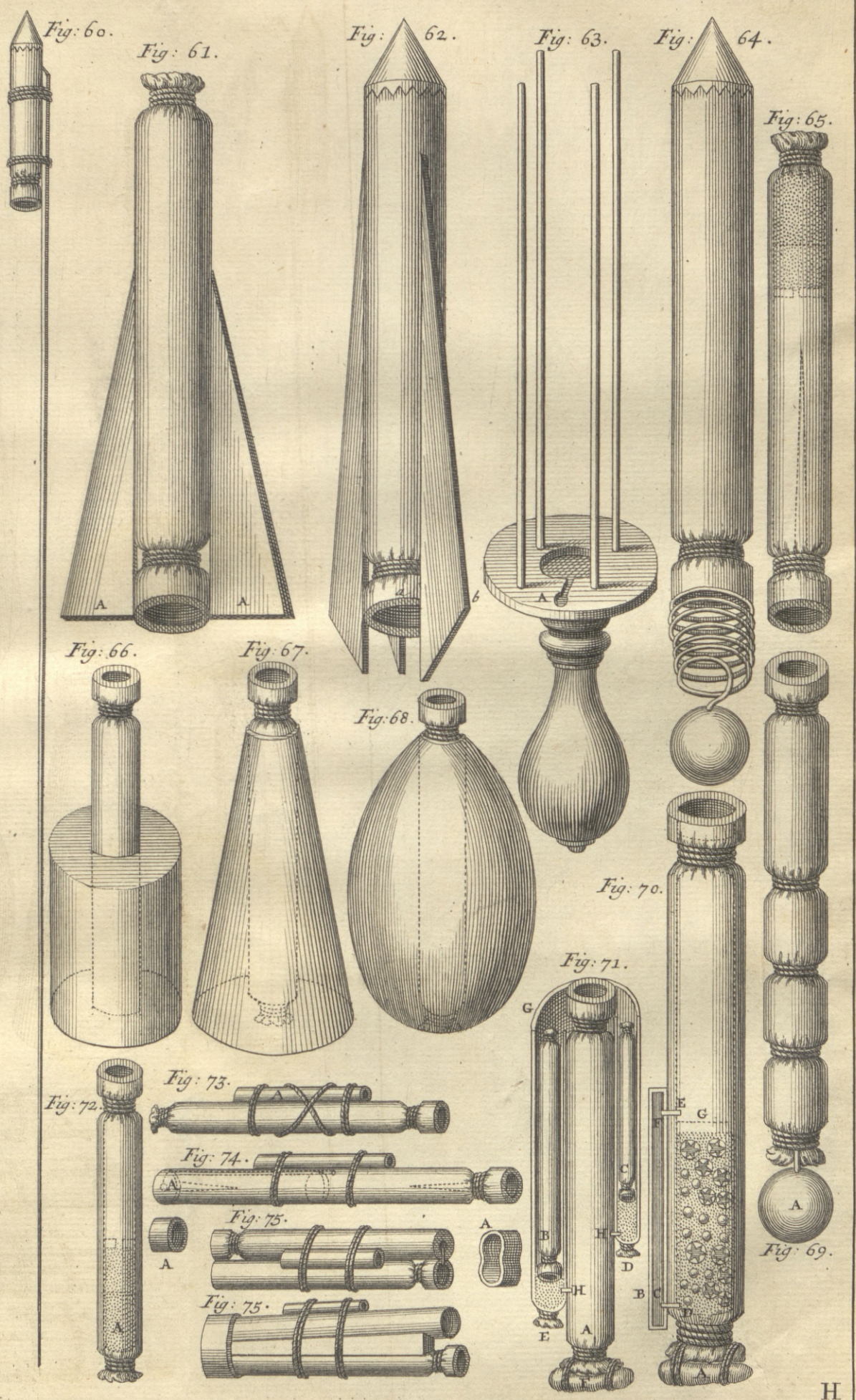
19. You ſhall not oblige them to move off with Burthens diſproportionate to their Strength; and though you are ſo exact as to load them with ſutable Weights, the *whole* muſt be adjuſted with regard to Form, ſo as that it ſhall with the moſt Eaſe cleave the Air, and riſe with the leaſt Oppoſition; ſo that their Burthens may in no reſpect retard their Riſing, which is a Motion the moſt unnatural and difficult to any Body. And this you are to obſerve the more nicely, the larger your *Rockets* are; which muſt retain in general (as much as poſſible) a Pyramidical or Conic Figure, as being the beſt adapted of any Shape whatſoever to pierce the Air, and to meet with the leaſt Reſiſtance from that Element. Tho' I muſt obſerve that a Spherical Form is the moſt convenient for a Body, which is to turn, rowl, and vault in the Air, becauſe of the Equality of its Surface.

20. You ſhall avoid as much as poſſible all Rainy, Damp, Miſty, and Foggy Nights; as alſo thoſe which are Tempeſtuous or Squally.

21. The different Effects produced by ſeveral *Rockets*, filled with one and the ſame *Compoſition*, muſt not be attributed to any other Cauſe, than their not having been treated with equal Diligence in every reſpect; whether in the Driving or Boring of them, and in many other Articles which ought to be ſtrictly obſerved. Or elſe to their having been laid up in Places of different Degrees of Dampneſs; and having thereupon contracted different Degrees of Moiſture, their Flight and Combuſtion will be various.

22. If you would have them make an Appearance in the Air like *Fire Rain*, or like a Cloud of *Fiery Sparks*, or like long and broad *Rays* darting downwards: You muſt mix your *Compoſitions* with a little of Glaſs coarſely powdered, of Filings of Iron, or Sawduſt of Wood. You may alſo contrive ſo as to have the *Fires* iſſuing from your *Rockets* of divers Colours. As for Example; if you mix a certain Quantity of *Camphire* in your *Compoſition*, it will yield a White, Pale, or Milky-Colour *Fire*. If you mix a little *Greek Pitch* in it, it will produce a Reddiſh Copper-Colour Flame. If *Sulphur*, you will have a Blue Fire. If *Sal Armoniac*, it will be Greeniſh. If Crude Antimony, the Flame will be of a ſad Yellow, or of an Honey or Box-Colour. If the Scrapings of *Ivory*, it will be of a bright Silver-Colour, inclining a little to the Livid or Lead-Colour. If the Raſpings of Yellow *Amber*, it will appear the ſame, but inclining to the Citroniſh. In ſhort, if you mix your *Compoſition* with common *Pitch*, your *Rocket* will caſt forth an obſcure gloomy *Fire*, or rather a black thick Smoke which will darken all the Air. The Sieur *de la Porte* (ſometimes called *Baptiſta Porta)* tells us in his *Natural Magic*, Book VII, and Chap. VII, that the *Loadſtone* being buried under Burning Coals, commonly emits a Flame that is of a Blueiſh, Sulphurine, or Iron Colour. Whoſoever doubts this, may make the

Expe-



P. Fourdrinier sculp:

Experiment by ſcraping a little of it into *Rocket Compoſition*, and ſee whether it be as he ſays or not: But however let him do it with Moderation and ſparingly, for fear leſt a diſproportionate Quantity of it ſhould deceive him in ſome degree or other. But I think, I have now ſaid enough concerning *Rockets*; and I fear, I begin to grow tireſome to the Reader, and that I ſhall ſtrain his Sight too much, if I keep him any longer looking up to the Sky. And indeed, I apprehend that I have left nothing unſaid that may be of Uſe to the diligent and expert *Pyroboliſt*, and that I have fully warned him, as to what he ought to embrace or fly; what he is to follow or avoid. But before I conclude this Book, I muſt obſerve that it is impoſſible to meet with any Artiſt ſo perfect, but that he may err ſometimes in ſome trivial Point, where ſuch a multiplicity of Circumſtances muſt be kept in Mind; therefore we ought not to paſs any Judgment upon a *Pyroboliſt*, nor infer any thing to his Advantage or Diſadvantage, from his good or bad Succeſs in the Conſtruction of *Rockets*. It would be endleſs to enumerate how many different Accidents may happen in carrying on ſuch tickliſh Works (though at firſt Sight they appear no other than Childiſh Amuſements) or even to tell of what Conſequence an almoſt incomprehenſible number of Particulars may be, which *Argus* himſelf with all the Eyes beſtowed on him by Fabulous *Antiquity* (in Alluſion to his great Sagacity and Watchfulneſs) would not be able to keep continual Sight of; much leſs avoid falling into ſome little Miſtakes, and conſequently would be far from providing againſt them all in general. Therefore all that can be done in this Caſe, is to take the Advice of good Maſters, and to conſult able *Pyrotechnicians*, who often lay their Hands to the Work; for I muſt own and declare, that I make no Account of certain Perſons who having no Knowledge in the Practical Part, yet arrogantly take upon them right or wrong to cenſure the Performances of thoſe who are incomparably more knowing than themſelves, with an envious Deſign of wounding their Reputation, or blaſting their Honour, or to inſtil a mean Opinion of them into thoſe who are ſometimes the moſt intereſted in the Loſs or Conſervation of the Perſons ſo decried. But what can we ſay to theſe malicious Cenſors that may affront them leſs than that Old Saying: *Ne Sutor ultra Crepidam, Let not the Shoemaker judge beyond his Laſt.* Now the whole Excellence, or univerſal Knowledge of *Pyrotechnics* doth not conſiſt in the Conſtruction of *Rockets*, which is but the leaſt Part of that great and noble *Art*; and accordingly we find that they are never employed but upon Tumultuous Rejoicings, on the ſcore of Victories obtained, Towns ſurrendered, or Sieges raiſed; or ſometimes at the Celebration of Marriages, or at Solemn Feſtivals to divert the Gueſts; and in ſhort, at public Bonfires exhibited to pleaſe the People only. Therefore we muſt not peremptorily conclude any Man to be well skilled in our *Art* that has a Knack at making *Rockets*; for we find but too many who will

make a *Rocket* well enough; but if you would go any farther with them, they will ask Pardon, and desire to be excused. In truth, it would be an arrant Shame, that such Fellows should assume the fine Title of *Pyrotechnicians*; for with equal justice might a Mountebank, a Country Barber, or a Farrier boast of being a learned Doctor of *Physic*. This then is not the utmost Point of Perfection in our *Art*, and we must believe that there is still something of a more exalted Nature, that properly and positively constitutes the true *Pyroboliſt*, who may justly bear the Authentic Denomination of *Master*. All our Inventions, and Fire Machines, together with that variety of Practice which will be exposed to your View in the Sequel of this *Work*, will give you a just Idea of the *Perfect Pyrotechnician*. I say then, again and again, for several Reasons, that it is impossible to deduce any Consequence to the Disadvantage of the other Parts of this *Great Art*, from the regular or irregular Ascent of *Sky-Rockets*; as was practised by the *Magicians* of old, who drew Conjectures with regard to Human Events from the Flight of Birds; and consequently that we ought not rashly (as I have already intimated) to condemn those, who happen ever to be unsuccessful in the Construction of *Rockets*. What I have here said is grounded upon sufficient Reasons, and is a real Fact; for I knew in my Time a *Master* of the *Ordnance* to a great Prince (whose Name I shall forbear here, tho' he has never spared mine) who thought there could be none more able in the *Pyrobolic Art*, than those who were well skilled in making *Rockets*; and accordingly not contented with caressing them and receiving them with open Arms, and admitting them into the Service of his Prince, and placing them in the Rank of *Pyroboliſts*; he by all his Endeavours fixed them deeply in the Favour of his Master, and continually represented to him, the Necessity there was, for that incomparable Knowledge they had in their *Art*. But he has since then perhaps been convinced (if he would be convinced; tho' at the Public Expence, and not at his own) that *Rockets* are in reality no other than Amusements; Inventions more properly calculated for the Diversion of People who would spend their Lives in Debauchery and Dissoluteness, than the true Thunder of War. And indeed he found by Experience that they were not even sufficient to shake the Enemy, much less to put them into Disorder; and that those whom he had, with so much Care, taught to make *Rockets*, were not only incapable of managing any War-like Machine with Skill and Judgment, at a Time when they were to tear the Enemy to Pieces; but also unworthy of the Title which he had too readily and liberally bestowed on them. As for himself, the *Story* says that not being able, or not daring to be present on the Spot, he was at a Place 40 *Miles* from thence whilst the *Tragedy* was acting; and was afterwards found in a snug Corner out of all Danger, and meditating this fine Saying in his Heart: *Beatus qui procul Negotiis. Happy the Man who is out of Harms-way.*

But

But God give him Grace to amend himſelf; ſo that laying aſide (if Shame does not prevent him) the Title and Office of Maſter, he may humble himſelf, and ſubmit to the *Ferula* of good and expert Profeſſors in our *Art*, and under them ſerve a commendable Apprentiſhip; receiving their Counſel no longer as impertinent or troubleſome Corrections, but as uſeful Inſtructions towards the regaining of his Reputation, and the re-eſtabliſhing his Honour. As for thoſe *worthy Gentlemen* his Diſciples, who once embraced his Inſtructions with ſuch Warmth, and looked upon whatever he ſaid as pure Oracles; I beg of them to know themſelves at laſt, and renouncing their falſe Doctrine, to think of purſuing more rational Schemes for the future, towards the Advancement of their Fortunes. But as it is impoſſible to recall what is paſt, and ſince it is *Sending for the Phyſician after the Man is dead*, to ſay any thing more about this matter; I ſhall only add that I believe this celebrated Doctor would pretty well cure his own particular Infirmity, and apply a Remedy to the Damage he has done to ſo many deſerving Perſons, if he for the future would continually keep in his Heart and in his Mouth theſe Words of the Prince of Orators: *Tibi ſemitam non ſapis & alteri monſtras viam. Thou thyſelf art blind, and yet wouldeſt guide others.*

OF THE

GREAT ART

OF

ARTILLERY.

PART *the* FIRST.

BOOK IV.

Of FIRE GLOBES *or* BALLS.

THE Word *Globe* is of a more extenſive Signification, and what we mean by it is much more various as to Form in *Pyrotechnics* than in *Geometry*; for you muſt not here think that *Globes* or *Balls* are perfectly Round Bodies, and contained under one Surface, according to *Euclid*'s Definition of the *Globe* and *Sphere* Book XI. Defin. XIV: but that we in general underſtand by it, ſeveral Bodies of various Kinds of Figure, all diſtinct and different from one another. For firſt, there are thoſe which are perfectly Round, ſome of which are Solid and others Hollow; of the former are all *Cannon* and *Muſquet Balls*, &c. and of the latter are *Grenado's* and *Bombs*, &c. which are ſeveral ways filled according to the Rules of *Pyroboly*. There are again *Balls* made in the Faſhion of an Egg; others of a Spheroid; ſome in Form of a Citron or Pear, or a Cylinder, and in ſeveral other Shapes which the Workman may give them. Beſides theſe of ſimple Kinds of Figure, there are others compounded, that is, that partake of ſeveral ſorts of Form together. And what is ſtill farther extraordinary, I have in the Magazines of the Earl of *Oldemburg*, and in ſeveral other Places, ſeen very old *Grenado's* that were ſhaped perfectly like a Cube or Parallelopiped. Now let their Qualities and Conditions

be

be what they will, and whatever Form or Figure they may bear, I beg the Liberty of calling them by the general Denomination of *Fire Globes* or *Balls*; at the ſame time obſerving to give them Sirnames and Epithets ſutable to their particular Properties and Effects, to diſtinguiſh them the better from one another. This is the Subject I propoſe to entertain you with in this Book, which we will divide into Two *Parts*. In the *Firſt* of which we ſhall ſhew you, and as it were make you handle (without any danger of burning your Fingers) all the Sorts of *Recreative Fire-Balls* both *Aquatic* and *Terreſtrial*, or ſuch as run and leap upon Horizontal Planes; and thoſe alſo which are projected from Mortars, which becauſe they perform their Parts in the Air may be properly enough called *Aerial*. The *Second Part* of this Book ſhall treat of all thoſe *Balls* which we call *Serious* or *Military*; that is, of all thoſe that are uſed upon Warlike Occaſions, as well to repel and oppoſe the Aſſaults of the Enemy, as to convey Fire and Dread into their Quarters, whenever it is needful. I hope it will not be taken amiſs that I here give the firſt Place to the *Recreative Fire-Balls*; for in ſo doing I only imitate Nature, who firſt forms the *Fœtus* in the Womb, which from Infancy advancing by degrees to Puerility, is thence gradually conducted to Virility, and at length compleated in perfect Manhood. Theſe Recreative Works of our *Art* are but the firſt Fruits, or rather the Seeds which produce the many fine Fruits of this noble *Science*. They are as it were the Lower Rounds of a great Ladder to the Higheſt of which none muſt hope to arrive: Or to lay aſide the *Allegory*, and ſpeak in direct Terms; none muſt expect to attain a thorough Knowledge of what concerns the terrible and wonderful Machines of War, but Thoſe of a fertile Genius, a robuſt Body, and of an Intrepidity not to be ſhaken by the horrid Bellowing of Cannon, nor diſmayed at the Tempeſtuous Iron Hail projected from thoſe mercileſs Thunderers. But let us have done with this, and take in hand the Subject we propoſed to treat of in this Book.

PART I. *of this* BOOK.

CONCERNING

RECREATIVE GLOBES.

CHAP. I.

Of Aquatic Globes, *or ſuch as* Burn *and* Swim *upon the* Water.

SORT I.

GET an hollow Wooden *Globe* made of what Size you think fit, and let both its Convex and Concave Surface be perfectly Spherical: The Thickneſs of the Wood throughout ſhall be $\frac{1}{5}$ of the Diameter A B, as you ſee in A C, or B D; and ſhall be ſurmounted by a Cylinder, whoſe Diameter E F ſhall be $\frac{3}{5}$ of the Diameter A B, and the Hollow of it G H ſhall not exceed $\frac{1}{5}$ of a Diameter aforeſaid. The oppoſite part of this *Globe* ſhall be opened, to receive a Tompion I K, of the ſame Diameter with the above Cylinder; by which Opening, the *Compoſition* muſt be put into the *Globe* when you would fill it; and through which you have the conveniency of putting a *Petard* or *Report* made of an Iron Plate in a Cylindrical Form, and which being filled with good *Corn Powder*, muſt be laid athwart as you ſee in M. The *Globe* being thus prepared, ſhall be filled with one of the *Aquatic Compoſitions*, which we ſhall hereafter treat of, and then ſtopped up with a Tompion that has been ſteeped in hot Pitch. This done, you ſhall run as much melted Lead over it as may be ſufficient to make it of equal Weight, or ſomething heavier than a Bulk of Water of the ſame Magnitude with itſelf. I ſhall tell you why this is done towards the End of this Chapter. In ſhort, this *Ball* being adjuſted after this manner, it ſhall be thrown into melted Pitch. When you would divert yourſelf with it, light the Priming, and as ſoon as you find, that the *Compoſition* is thoroughly inkindled throw it into the *Water*. *Fig.* 80 repreſents this.

Fig. 80.

SORT

SORT II.

This *Ball*, which you ſee repreſented in *Fig.* 81, differs from the abovementioned no farther, than that the Form of it is not Spherical but Spheroidical; and the Section parallel to the Axis of it is Oblong. The Thickneſs of the Wood throughout the whole, its Tompion beneath and its Vent-hole B, obſerve the very ſame Proportions as in the above-deſcribed *Globe*. Beneath it you have a Leaden Grenade diſtinguiſhed by A, charged with *Corn Powder*, the Neck or Fuze of which goes into the Bottom of the *Globe*, as the *Figure* ſhews you. In ſhort, it muſt be filled with one of the *Aquatic Compoſitions* I ſhall hereafter give you; and then well coated with Pitch, before it is thrown into the Water. Fig. 81.

SORT III.

You ſhall get an hollow Wooden Cylinder, made by a Turner, of the Height A D or B C, which ſhall be 1 ½ of the Breadth A B or D C; it ſhall at Top be ſtopped up with a Wooden Tompion with an Hole in the Middle of it, of a Conic Form to hold the Priming, the inferior Breadth of which E F, ſhall be ⅓ of the Height of the *Globe*, and the ſuperior Breadth of it G H, ½ of the Inferior. You ſhall fill it with one of the *Compoſitions* I ſhall hereafter give you, and ſtop it well up with a Tompion, after having wrapp'd it round with a piece of Cloth dipped in hot Pitch or Tar; beneath it you may fix a *Grenade*, or a *Report*, as you ſee in M. The whole being thus ordered, you ſhall near the Vent-hole fix an *Æolipile*, as you ſee in L, which is to be contrived after the following Method. Get a Founder to caſt you a ſmall hollow *Globe*, (or it may be of any other Form if you will) or elſe you may make it by ſoldering two Hemiſpheres together; from the Top of it ſhall iſſue two hollow tapering Pipes like Horns, but let their Cavities be as ſmall as you can poſſibly make them, eſpecially towards the Extremities of them; in ſhort, their Diameters may be equal to ⅛ the Diameter of the Subſtance of their reſpective Pipes. Being thus adjuſted, cover it with *Burning Coals*, and let it there remain till it is red hot: Take it burning as it is, and put the ſmall Pipes of it inſtantly into Water, and let them be immerſed a little till the *Æolipile* is quite cold; during which time it will have imbibed a certain Quantity of Water, more or leſs according to the Bigneſs of it. This *Ball* or *Æolipile* being ordered as we have now directed, you ſhall ſecure it faſt near the Vent-hole of the *Water-Globe* with ſmall Nails or Pins running through a little Handle adjoining to the Lower Part of it. This done, you ſhall fix two ſmall Leaden Flutes or Tubes on each ſide of your *Water-Globe*, ſuch as you ſee in I and K (in the ſame *Figure)* ſo contrived that their Upper Orifices may exactly fit the Extremities of the Pipes of the *Æolipile*. Having done Fig. 82.

all this ſet fire to the Priming with the End of a Match, and when the *Compoſition* is accended and got to a ſtrong Head, throw it into the Water; and in a little time the *Fire* iſſuing from the Vent heating the *Æolipile* to that degree as to make the Water in it boil, it will diſcharge its Steam through the ſmall Pipes with great Violence, which ruſhing into the Flutes above-mention'd, they will yield an odd kind of Harmony.

Fig. 82. *Fig.* 82 will give you an exact Idea of this.

SORT IV.

Fig. 83. In *Fig.* 83 you have the Repreſentation of a *Water-Globe*, which the *Germans* call *Binſchwerm*. This needs no particular Deſcription to illuſtrate it, for the *Figure* explains itſelf. The Height of this *Globe* ſhall be proportioned to the *Running Rockets* it is deſigned to contain, tho' it is generally made 1 ½ as long as it is broad. The Wooden Tube diſtinguiſhed by A, ought to be equal in Height to the *Globe*; and ſhall be filled with a *Compoſition* of 3 Parts of *Powder*, 2 of *Saltpeter*, and one of *Sulphur*. You again, are to add underneath it a Paper *Cracker*, as you ſee in C; D is a piece of Lead ſerving for a Counterpoiſe; in ſhort, you muſt add a round piece of Board to buoy it up upon the Water, a *Profil* of which is repreſented by B.

SORTS V, and VI.

Fig. 84. and 85. In *Fig.* 84 and 85 I preſent you with the Conſtruction of two *Water-Globes*, which have a near reſemblance to one another as to Effect, but very little Affinity to each other as to Form. In the *Firſt* of theſe, the Middle of it A, is filled with an *Aquatic Compoſition*, which muſt be ſtopped up with a Wooden Tompion as you ſee in H; which muſt be pierced through and through in the Middle to receive the Priming. In B and C you have certain Hollows or little Receptacles for holding ſmall and great *Rockets*. The Letters E and D point out the ſmall Tubes of Communication, through which the *Fire* is conveyed to the *Rockets*. F is an Hole through which the *Fire* has Paſſage to the Leaden *Grenade*, or a *Cracker*, one of which we uſually faſten to the Bottom. So much for the Firſt *Figure*, proceed we now to the *Second*. You are to fill the Middle of this, as well as that of the former, with an *Aquatic Compoſition*, as you ſee in A. This *Globe* incloſes two Orders or Sorts of *Rockets* (*viz.*) Greater as B, and Smaller as C. The two Tubes which convey the *Fire* from the Body of the *Globe* to the two *Rockets* are denoted by H and N. D is a *Report* of *Corn Powder*, which is ſeparated from the *Compoſition* by the Wooden Partition E, which has an Hole bored through the Middle of it. Farthermore F is a Cap that covers the *Compoſition*, which is in like manner perforated in G, where you are to ſet *Fire* to the Whole. You may make Covers or Heads of

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paſted Paper, or of Canvaſs dipped in Glue, and ſometimes made of an Iron Plate, with which you cover the Tubes M and N, which hold the *Running Rockets*, in order to hide them. In ſhort, O and P are two Cavities or Grooves which are to be filled with *Meal Powder*, to fire the *Rockets* which are placed over them. The *Profil* of this will fully inſtruct you.

SORT VII.

Get a Wooden *Globe* that is perfectly Round and Hollow within, and pierce the Outſide of it with certain Cavities, of ſufficient Capacity to receive a *Running Rocket*; however take care that they be not made ſo deep, but that there be the Thickneſs of a Finger of the Wood, between the inner Extremities of them and the *Aquatic Compoſition*, contained in the Middle of the *Globe* A. That the aforeſaid *Compoſition* may have a Communication with the *Rockets* which are thruſt into the Cavities above mentioned, you ſhall bore the Wood between them with a fine Gimblet, or with a red hot Iron Pin, juſt as you ſee in B; which Hole ſhall be filled with *Meal Powder*. This done, the *Vertex* of the *Globe* ſhall be ſurmounted by a Wooden Cylinder or Tompion, crowned with the Hemiſphere C, made hollow to receive the Priming. In the oppoſite Part or Bottom is a Tompion D, which is likewiſe hollow to give Paſſage to the Fire, that it may enkindle a *Cracker* which we commonly fix beneath it. In ſhort, E points out a Leaden Counterpoiſe which is deſigned to keep the whole upright in the Water. See *Fig.* 86. Fig. 86.

SORT VIII.

The Form of the *Globe* in *Fig.* 87 is not Simple in its Conſtruction like the foregoing, but is pretty Complex; for its Lower Part is an hollowed Cylinder, which is ſurmounted by a Concave Hemiſphere as G. The Cylindrical Part is filled with *Paper Crackers* as C, and the Hemiſpherical Part with an *Aquatic Compoſition* as may be ſeen in A. This *Compoſition* is ſeparated from the *Crackers* by a Wooden Partition D; through which paſſes a Wooden Tube as B, whoſe lower Extremity muſt fall ſhort of the Bottom of the *Globe*. This Tube muſt be filled with ſuch a *Compoſition* as I preſcribed for the Fourth Sort of *Globes*. Beneath all, is a Paper *Cracker* as E, and a Leaden Counterpoiſe as F. H is the Vent-hole, where you muſt prime your *Globe* in order to fire it. Fig. 87.

SORT IX.

The *Water-Globe* you ſee in *Fig.* 88 is a Spheroid, though you may have it perfectly Round if you will. The Body of this muſt be filled with one of the *Compoſitions* we ſhall hereafter give you. The Outſide Fig. 88.

or Convex Surface of it is fluted or hollowed in ſeveral Places, for the more conveniently fixing of *Crackers* to it. Theſe are diſtinguiſhed by the Letter A. On one Side of the *Figure* in Letter E, you have the Form of theſe *Crackers*, which are to be laid in the above-mentioned Flutings, to each of which belongs a little Iron or Copper Fuze, which muſt be filled with *Meal Powder*, and ſo ordered as to fit the ſmall Holes you ſee in the Flutings, and which are diſtinguiſhed by B. Through theſe the *Fire* has a Communication from the Body of the *Ball* to the *Crackers*. F points out the little Fuzes before-mentioned, and ſhews how they are to be fixed to the *Crackers*. C is the upper Orifice for the Priming. In ſhort, D is its hollow Tompion, through which the *Fire* is communicated to the Whole.

SORT X.

Fig. 89. As for the Conſtruction of the *Globe* Fig. 89, you will readily conceive it, the *Figure* explaining itſelf; therefore I ſhall not trouble you with a particular Detail of it. I ſhall only obſerve that the little Chamber A at Bottom ought to be $\frac{1}{3}$ of the Breadth of the whole *Globe*, and that its Height ſhould be $1\frac{1}{2}$ of its Breadth. Secondly, that the *Water-Ball* B, ſhall be as we ordered in the Firſt Sort, and on all Sides incompaſſed with an *Aquatic Compoſition* as may be ſeen by H. That the Chamber A ſhall be covered by the Partition C, to the end that when the *Powder* in it ſhall have the *Fire* conveyed to it, through the Pipes or Tubes E, F and G, it may with the more Eaſe and Force blow up the *Ball* in the Belly of the Firſt; which taking fire at the Hole D, will burn upon the Water, and will ſoon after to the Aſtoniſhment of the Beholders blow up the other *Ball* that was in it. In fine, I muſt caution you to ſecure the piece of Wood that covers the Whole as well as poſſible, for fear it ſhould be blown up by the *Compoſition* of the greater *Globe* before it is all burned out.

SORT XI.

Fig. 90. If you conſider the *Globe* repreſented in *Fig.* 90 as to its Effect, you will find that it has a perfect Reſemblance with that we have been juſt now deſcribing; except that inſtead of containing a Spherical *Globe* in its Cavity, it has Iron *Petards* or *Crackers*, as may be ſeen by the Letters B and F; beſides that it retains the Form of a Cylinder, and is flat both at Top and Bottom. Above the *Crackers* it is filled with an *Aquatic Compoſition*, like that above deſcribed, as may be ſeen by A. The Tube C which goes through the Body of it, and touches the Matter contained in the Chamber D, ought to be filled with ſuch a *Compoſition*, as we directed for the Fourth Sort of theſe *Globes*. Near the Lower Extremity of this Tube you ſhall bore an Hole as E, by which the *Fire* may have Paſ-

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ſage to the *Crackers* when the *Globe* is blown up. In ſhort, the Chamber D in the Part where it is broadeſt ought to be $\frac{1}{3}$ of the Breadth of the whole *Globe* itſelf, its Height ſhall be $\frac{1}{4}$, but underneath it will be ſufficient if it is $\frac{1}{5}$ of the aforementioned Breadth. G is a *Paper Cracker* which is made faſt beneath all. H is a little Communication between the Chamber and Cracker.

SORT XII.

As to the Conſtruction of the following *Globe* (*Fig.* 91.) You firſt muſt Fig. 91. have an hollow Wooden Cylinder made, having in the Bottom of it a Chamber which may be filled with *Powder*: Its Orifice ſhall be at leaſt one Foot in Diameter, and its Height 1 $\frac{1}{2}$ of its Orifice. Being thus, you ſhall adjuſt a round Board whoſe Convexity may exactly fit the Concavity of the *Globe*, and freely ſlip down into it: Beneath this Board ſhall be a Wooden Tompion to confine the *Powder* in the Chamber, and through this Tompion ſhall paſs an Iron Tube filled with *Meal Powder*, or with that *Compoſition* we mentioned for the Fourth Sort of theſe *Balls*. You will ſee the Repreſentation of all this in the *Figure* under the Letters A, B, C, D, E. In the Third Place you ſhall prepare 6 *Water-Balls* or more, as you ſhall think proper, of the ſame Form as we deſcribed in the Firſt and Second Sorts, or any of the foregoing, each of which ſhall have an Iron Fuze in its Orifice filled with good *Meal Powder*. Let all theſe *Balls* be of ſuch a Size, that being diſpoſed in a circular Form, and joined cloſe to one another, the imaginary Circle they are contained in, may not exceed the inner Circumference of the great *Globe*, in which you would lodge them, that is, that they muſt as exactly fit each other as poſſible. This done, and having charged the Chamber of the *Globe* with *Corn Powder*, you ſhall let down the round Board with its Tompion before mentioned into the *Globe*, and upon that you ſhall range in a perpendicular Situation the 6 *Water-Balls* all round the Iron Tube; which *Water-Balls* muſt be ſurmounted by another round Board, with 6 Holes bored through it, which muſt exactly fit the Fuzes in the Orifices or Vents of the ſaid *Balls*, and be at ſuch diſtances as nicely to correſpond with the ſame Fuzes; which running up through them ſhall riſe a little above the ſaid Board. The better to conceive this, caſt your Eyes upon the *Figure* at the Letter G. This laſt Board or Partition ſhall be ſpread over with a good Quantity of *Meal* and *Corn Powder* mixed together, and upon that ſhall be placed as many *Running Rockets* as the *Globe* can hold. In the midſt of theſe ſhall be fixed a large *Rocket* (which muſt not be bored) into whoſe Orifice the Iron Tube (before mentioned) beneath may enter; this Tube is the ſame which you ſee in H; and ſhall be pierced through and through all round, upon the Plane of the aforeſaid Partition; to the end that the *Fire* having a Communication through them it may accend the *Running Rockets*, and

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at the ſame time inflame the *Water-Balls* whoſe Fuzes riſe up through the Partition; and from thence, after having penetrated down to the Chamber beneath, it may be ſprung, and blow up the Whole into the Air, and make itſelf be heard. In this *Figure* the Letter F points out the 6 *Water-Balls*, K the Great *Rocket* in the midſt of the *Running* ones; L the Chamber for the *Powder*; M is a Communication to convey the *Fire* to the Paper *Cracker* N. In ſhort, this *Globe* being adjuſted after the manner we have now directed, it ſhall be well caſed and envelopped with a proper Covering, and thrown into Tar to preſerve it from the Water.

SORT XIII.

The *Water-Globe* I am now going to deſcribe, and which is repre-
Fig. 92. ſented in *Fig.* 92, is by the *Germans* called *Waſſer Pumpe*, by which they mean a Pump or Pipe, or any ſuch Hydraulic Contrivance; they again call it *Waſſer Morſer*, which ſignifies an *Aquatic Mortar-Piece*, or a *Mortar* that will ſerve upon the Water; and is to be conſtructed after this manner. Take ſeven Wooden Pipes or Tubes, and wrap them round together, with a Tarred, Pitched or Glued Cloth, and gird them firmly round with Cord or Mar-line. Their Height, Breadth and Thickneſs of their Wood, may be ordered as you ſhall think proper; except that you muſt allow the Middle *one* a ſomewhat greater Height than the reſt: Theſe Tubes then (having the higheſt in the Middle of them) ſhall be bound up together in one Cylindrical Body, as may be ſeen in D. Beneath the inferior Extremities of them you ſhall fix, (by way of Baſe or Bottom) a round piece of Board as you ſee in C, to which you ſhall faſten theſe Tubes with ſmall Nails; and be not ſparing of Glue to ſtop up all the Cracks or Creviſes to prevent the *Compoſition* from taking Air. This done, you ſhall fill your Tubes according to the Order you may obſerve in *Fig.* A. Firſt you ſhall pour into each of them a little *Corn Powder*, to the Height of about half an Inch; and upon that, put a *Water-Ball* as you ſee in G; upon that, *ſlow Compoſition*; and then *Corn Powder* again; and then a *Water-Globe* filled with *Running Rockets*, as may be ſeen in H; and upon that again *ſlow Compoſition*, then *Corn Powder*, and then a *Light Ball* as may be ſeen in I. Over this you ſhall a third time put *ſlow Compoſition* and *Corn Powder* as before, which ſhall be covered with a Wooden Cap: Upon this Cap you ſhall ſet *Running Rockets*, but not ſo cloſely together, but there may be room between them for a Wooden Caſe filled with an *Aquatic Compoſition*. In ſhort, to conclude, you ſhall fill the Remainder of the Tubes with *ſlow Compoſition*, and then ſtop them well up. All your Tubes being filled after this manner, you ſhall get a ſquare or round piece of Wood, no matter which, with an Hole in the Middle of it, big enough to receive the Ends of all theſe Tubes thus bound together, which you ſhall ſtop near the Tops of them to buoy them up, and preſerve the *Powder* or *Compoſitions* from being Wet.

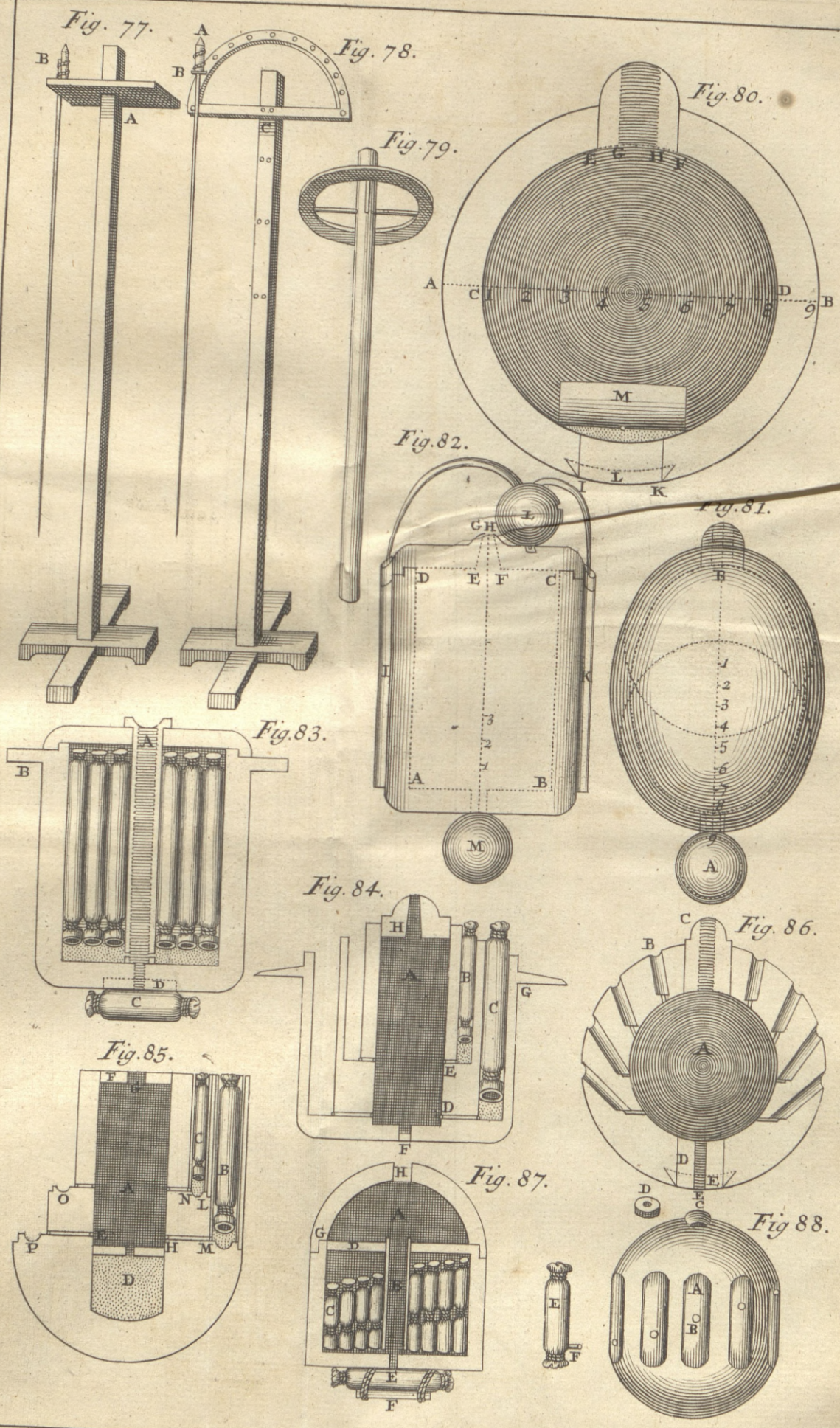
Fig. 77.
Fig. 78.
Fig. 79.
Fig. 80.
Fig. 81.
Fig. 82.
Fig. 83.
Fig. 84.
Fig. 85.
Fig. 86.
Fig. 87.
Fig 88.

I

P. F. sc.

Wet. This Float-Board is diſtinguiſhed by the Letter L. The whole being prepared purſuant to the Directions here given ſhall be dipped into a Quantity of Tar. Then ſhall the *Rocket* M be ſtuck into the Oriſice of the Middle Tube, or inſtead of it, a ſmall Wooden Tube filled with a ſtrong *Compoſition*, and that will burn upon the Water (as I have ſo often mentioned) which is the ſame with the *Compoſition* I ordered for the Fourth Sort of *Balls*. As to any thing farther relating to this you may readily trace it out from the *Scenographical Figure*, which we have here drawn.

Obſerve here in the Firſt Place, that it is neceſſary that the Middle Tube ſhould have a little more *ſlow Compoſition* in it than thoſe which encompaſs it.

In the Second Place, take Notice that if you would have all theſe Collateral Tubes take *Fire* at once, you muſt pierce the Sides of the Great one with ſmall Holes, each of which ſhall correſpond with one of the Tubes, by which means the *Fire* may be conveyed to all of them at once, and conſume them equally and in the ſame time. But if you would not have ſuch a quick Conſumption of them, but on the contrary would have the Pleaſure of ſeeing them burn one after another, you muſt head them well up with ſtrong Paper, and to each Tube fix a little Pipe of Communication, filled with *Meal Powder* or a *ſlow Compoſition*, through which the *Fire* may be conveyed from the Bottom of that which is conſumed, to the Orifice of that next to it, and ſo on ſucceſſively to ſuch as have not been fired.

COROLLARY I.

Of Odoriferous, or Perfumed Water-Balls.

GET a *Turner* to make you ſome hollow *Balls* of the Bigneſs of a Walnut or Crab, which you ſhall fill with one of the following *Compoſitions:* Being all ready and filled, you ſhall, after having lighted them, throw them into Water; (this I underſtand to be done in ſome Room or Apartment) but firſt you ſhall add a little *quick Match* to them made of our *Pyrotechnic* Tow, or Cotton Wyck, that the *Compoſition* may be lighted the more conveniently. Theſe *Compoſitions* are as follow:

Take of *Saltpeter* ℥ iiij, of *Storax Calamita* ℥ j, of *Frankincenſe* ℥ j, of *Maſtic* ℥ j, of *Amber* ℥ ſs, of *Civet* ℥ ſs, of Sawduſt of *Juniper* ℥ ij, of Sawduſt of *Cypreſs* ℥ ij, and *Oil* of *Spikenard* ℥ j; make your *Compoſition* of theſe according to Art and the Method laid down.

Or elſe take of *Saltpeter* ℥ ij, of Flower of *Sulphur* or *Brimſtone* ℥ j, of *Camphire* ℥ ſs; of the Raſpings of *Yellow Amber* finely pulverized ℥ ſs;

of Coal of *Lime-Tree-Wood* ℥ j; of *Flowers* of *Benjamin* or *Aſſa Odorata* ℥ ſs. Let them be finely pulverized, then mixed and incorporated together.

COROLLARY II.

Of the Compoſitions *for* Water-Globes *or* Balls, *which burn as well upon the* Water *as in it.*

I.

FIRST take of *Saltpeter* finely mealed 16 ℔; of *Sulphur* 4 ℔; of the Sawings of Wood that have been previouſly boiled in a Saltpetrous *Lye* or Water, then dried, 4 ℔; of good *Corn Powder* ℔ ſs; of the Shavings of *Ivory* ℥ iiij.

II.

Take of *Saltpeter* 6 ℔; of *Sulphur* 3 ℔; of *Meal Powder* 1 ℔; of the Filings of *Iron* or of *Hammer-ſlaw* 2 ℔; and of *Greek Pitch* ℔ ſs.

III.

Take of *Saltpeter* 24 ℔; of *Meal Powder* 4 ℔; of *Sulphur* 12 ℔; of *Sawduſt* 8 ℔; of *Amber Powder* ℔ ſs; of *Glaſs* coarſely powdered ℔ ſs; of *Camphire* ℔ ſs.

You muſt obſerve the very ſame Rules in the Preparation of theſe *Compoſitions*, as we taught with regard to thoſe deſigned for *Rockets*; except that the *Ingredients* need not be ſo finely mealed, but they muſt be to the full as well mixed and incorporated. You muſt take care that your *Compoſition* be not too dry when you would fill your *Globes*; and for this Reaſon it ſhall be moiſtened with a little of the Oils of Linſeed, Olives, *Naptha* or *Petrol*, Hempſeed or of Nut, or any other Fat Subſtance that is ſuſceptible of *Fire*.

Beſides the *Aquatic Compoſitions* above-given, from my own Expeperience, you may contrive others at pleaſure, by obſerving to take the *Ingredients* in different Proportions to one another. This indeed you will find eaſy enough; but I would have you try them from time to time, before you exhibit them publickly. It will be of very great Importance to ſuch as would have a perfect Knowledge of the Nature of *Compoſitions*, to be extremely well acquainted with the particular Virtues, Properties and Effects of each *Ingredient* they are compoſed of; for as *Ariſtotle* ſaith in *Lib.* VII. *Cap.* X. of his *Phyſics*, *Ex particularibus præcognitis univerſalis acquiritur Scientia: The Knowledge of particular Things leads us to univerſal Science:* Therefore I muſt deſire you to conſider attentively what I am going to ſay to you of all theſe *Ingredients* ſeparately.

Gun-

Gun-powder is the Firſt and Principal of them all, the moſt violent when accended, and burning more outragiouſly than any of the reſt: Whence it is that it powerfully reſiſts all kind of *Moiſture* to prevent its Flame from being ſuppreſſed by it.

Saltpeter well purified may be placed in the Second Rank. We have treated largely of this when we had occaſion to ſpeak of its Nature and incredible Virtues in *Gun-powder:* But beſides what we have ſaid of it, we ſhall add, that it has an unaccountable, particular Quality, of repelling and diſperſing the Drops of Water which preſent themſelves near the Orifices of *Water-Globes*, &c. which muſt be owing to its *Windy Expanſion.*

All *Oils* mixed with the *Compoſitions* in moiſtening them, when they are well united with the other *Ingredients*, keep up the *Fire* in ſpite of the Water, and ſeem to ſide with it to prevent its Extinction; and this becauſe of a Fat Humour, together with a very Aerial and Igneous Subſtance natural to them, which the *Fire* embraces with ſuch Eagerneſs that it is impoſſible for them to diſengage themſelves from that Element, when once caught hold on by it; and as all *Oils* are of a pretty denſe and tenacious Subſtance, and their Parts not to be disjoined or diſperſed eaſily, it is a hard matter for *Water* to diſpoſſeſs the *Fire*, when thoroughly poſſeſſed of ſuch *Oils*; and for the very ſame Reaſon it is that Water is incompatible with them, and cannot inſinuate itſelf into them, and more particularly when there is a powerful *Maſter* within, who rages, and reſolves not to quit his hold, till he has firſt removed every thing belonging to him, and devoured all that can be converted into his own Form or Subſtance.

Sulphur has very great Virtues, which indeed for their Excellence ought to hold the Firſt Rank; for from this *Ingredient* it is, that all the *Compoſitions* we have mentioned derive a great part of their Strength, and would infallibly be imperfect without it: Inaſmuch as it is the particular Office of *Sulphur*, to conceive the *Fire* upon all Occaſions, and having once conceived it to communicate it to the other *Ingredients* with which it is incorporated. In ſhort, I believe there cannot be found any kind of Fat or Bituminous Subſtance, that can be comparable to this, as well for retaining and preſerving a *Flame* when once conceived, as for protecting and defending it againſt all Enemies who by the Contrariety of their Qualities endeavour to deſtroy and ſuppreſs it; and this proceeds from a certain Sympathy between *it* and *Fire*, or from a natural Parity of Subſtance; or from ſome unaccountable occult Friendſhip mutually ſubſiſting between them, and which renders them inſeparable whenever they meet together.

Amongſt the rare Qualities of *Camphire*, that of retaining and preſerving an inextinguiſhable *Flame* is none of the leaſt, and it may boaſt of being the only Oily, Bituminous, or Fat Subſtance to whom *Nature* hath granted ſo extraordinary a Property. But be this as it will, we by Experience

perience find, that without the help of any other *Ingredient* it burns in the midſt of the Dampeſt Things, and maintains its Combuſtion with ſuch Obſtinacy, that it ſeems as if it would give Laws to them, even in their own proper Element. If you doubt this, light a piece of it and put it upon Ice, or if you will in Snow (taking care not to bury it cloſe up, but to leave an Opening for the Air) and you will ſee that it will melt, both the one and the other, and ſupport itſelf, notwithſtanding their Frigidity, to its utter Conſumption. Moreover, being pulverized, then lighted, and ſcattered over the Surface of Water, it produces an agreeable Appearance; for it ſeems as if the Water itſelf, upon which it floats becauſe of its Lightneſs, was all inflamed. However you muſt underſtand that it does not conceive the *Fire* ſo readily from any particular Heat that is natural to it, but becauſe it is of a very ſubtile Fat Subſtance. From whence happens that ſtrange and admirable *Phænomenon*, that if you throw ſome *Camphire* into a Baſon which has *Brandy* in it, and let it boil to its univerſal Evaporation, in ſome cloſe Apartment, it will be rarified and converted into ſo fine a Vapour and ſuch ſubtile *Effluvia*, that the Door being opened ſome time afterwards, and you immediately enter into the Place with a lighted Torch, all the Air in the Room will inſtantly take fire, and appear like a Flaſh of Lightning, without doing the leaſt Damage to the Building, or without in the leaſt hurting any of the Spectators. This ariſes from the extreme Subtility of it: For you muſt think that *Fire* will not burn, except when its Parts are very cloſely united: And this may be farther obſerved in the Paper of this Country, which being in a Blaze you may freely paſs your Hand over it, without any danger of being burned. The ſame is it with Brandy, which emits ſo fine a Flame that an Handkerchief being dipped into it, it will be conſumed from one End to the other of it, without hurting the leaſt Thread of the Handkerchief.

All Sorts of *Pitch* and *Bitumen*, amongſt which we may reckon the Raſpings of *Yellow Amber*, (though it has naturally no great Affinity with them, as we ſhewed formerly from *Scaliger)* produce a ſtrong Smoke, which retaining a great deal of *Fire*, and much Aerial Spirit in it, muſt conſequently be very light, and tend upwards; and therefore breaking violently through the moſt cloſely united Parts of the Water, it ſerves as a Forerunner to the *Fire*, and clears the Way for it, to aſpire in its natural Direction: For being collected in little Whirlwinds under the Water, it briskly blows up the ſuperincumbent Liquid which oppoſes its Excurſion, and cauſing at the ſame time a great number of large Bubbles upon the Surface of it, declares its Reſolution of not ſubmitting to an Element which is ordained by Nature to lye beneath it.

The *Sawduſt* of Wood, *Filings* of Iron, and *Powder* of Glaſs, being heated by the other *Ingredients* which are more combuſtible than they, are blown up aloft by the Strength of the *Powder* and *Saltpeter*, where appearing

appearing like a Cloud or Shower of Sparks they yield an agreeable Proſpect to the Eye, and immediately falling down again upon the Surface of the Water (hot as they are) you hear a Succeſſion of ſmall Noiſes which are by no means diſagreeable. Now you muſt know that theſe Things are not uſed in *Compoſitions* purely to pleaſe the Eye or Ear; but they alſo greatly reinforce the *Fire* by keeping its Rays united; which is one Reaſon why it is able to ſubſiſt in any kind of Liquid. And indeed their real Office is to increaſe the *Fire*; for from its great Redundance, and Denſity it is, that it contemns the Attacks of its Enemy; and this we may reaſonably affirm if ſo it be, that thoſe Powers which are the moſt perfectly united are always the ſtrongeſt. The Strength of theſe *Ingredients* is not a little added to, by their Confinement; becauſe the Limits preſcribed, being unequal to their violent Expanſion, they ruſh with great Impetuouſneſs through the *Vent* or Orifice of the *Ball*, or whatever elſe contains them; and thus *Scaliger* tells us, That Reſtraint adds to their Force.

I have now done with what I propoſed to ſay concerning *Aquatic Compoſitions*; which may be of great Uſe to the *Pyroboliſt*, if he gives due Attention to it, and at the ſame time ſtudiouſly conſiders the ſeveral Particulars we have here handled.

Give me leave to entertain you now with a *Story*, relating to the different Properties of *Fire* and *Water*, and the mutual Power they exerciſe over each other when they contend for the Soveraignty.

This *Story* is pretty common, and is related by *Philander* from *Suidas*, in the Preface to *Lib.* VII. of *Vitruvius*. *Ruffinus* alſo mentions it in *Eccleſiaſt. Hiſtor. Lib.* II. *Cap.* XXVI. nearly in theſe Terms: *At the Time when the* Chaldeans *ſacrificed to* Fire *as to a Divinity whom they revered above all other Celeſtial and Elementary Powers; boaſting that their God alone was able to ſubdue all Things, and conſequently (according to their way of arguing) it was but juſt and equitable, that thoſe Honours ſhould be paid to him which had been uſually given to others: Adding that the Gods of other Nations, whether made of Braſs, Silver or Stone, or any other Materials whatſoever, were unable to withſtand him, and that he devoured all that came in his Way: It happened that the Prieſt of the God* Canopus *heard of this; who being a Man of Wit and Cunning, he undertook to undeceive them, and to demonſtrate that there was ſtill a* Power, *to whom their* God *would be obliged to yield: And in order to this, he cauſed a large Pitcher to be made full of Holes, which was well coated over with Wax, and painted of ſeveral Colours, and then filled with Water. This Pitcher being thus prepared, he fixed it upon the Shoulders of a great Statue (which he pretended to be the Statue of* Menelaus) *inſtead of the Head which he had taken off. In a little time after, the* Chaldeans *coming to be Witneſſes of this deciſive Contention between their Deity and the other, they let looſe the* Fire *at him, who ſtock ſtill expected his Adverſary's Aſſault. At firſt* (the *Story* ſays) *the* Fire *animated by the Sight of ſo mighty a* Coloſ-

ſus, *laid hold on him with ſuch Violence and Obſtinacy, that every one preſent concluded* he *muſt remain Maſter of the Field, eſpecially when they beheld the Immobility and Inactivity of his* Antagoniſt. *But Fate would have it otherwiſe, and ſoon made the Spectators of a different Opinion; for in a little while after this great Body had been thoroughly heated, and that the Fire had diſſolved the Bonds which kept his Enemy impriſoned in the Scull of the Statue; he inſenſibly found himſelf ſeized with a cold Sweat, which trickling down from Head to Foot, ſoon ſlackened his Heat, and deprived him of all Hopes of the Victory he had promiſed himſelf. In ſhort, the Combat did not hang long in Suſpence; for the Holes of the Pitcher being by this time all opened, the* Water *guſhed out furiouſly upon him, and overwhelmed him on all ſides; ſo that in expiring he was obliged to acknowledge that he was overcome, and that* Water *ought to be preferred to him. The* Chaldeans *equally aſhamed and afflicted to ſee their once-favorite* God *in this deplorable Condition, retired diſſatisfied with the Combat, and from that Time forwards forſaking* Fire, *they ſided with the* Egyptians. This was the Event of the *Canopian* Prieſt's Stratagem.

COROLLARY III.

Of the Due and Proper Weight *of each* Water-Globe.

I AM now going to perform the Promiſe I made you, in my Deſcription of the Firſt Sort of *Water-Globes*. It is then very evident from the Experiments that have been made, and even from the Demonſtrations of *Archimedes* (in *Lib.* περὶ των ἐχομένων, &c. *ſeu de Inſidentibus Humido*, Prop. 3, 4 and 7.) where he ſpeaks of Bodies immerſed in Water, *That* Solids *of equal ſpecific Gravity with* Water, *or any other* Liquid, *being immerſed into it, will remain ſuſpended in it, and will be ſupported by it, neither ſinking beneath nor riſing above the higheſt Surface of it. But* Solids *which are ſpecifically lighter than a* Liquid, *will upon being immerſed in it, aſcend above the higheſt Surface of it in a certain Proportion. In ſhort,* Solids *which are ſpecifically heavier than a* Liquid, *will ſink down to the Bottom, and loſe as much of their Weight whilſt in the* Liquid *as a Bulk of the* Liquid *equal to themſelves in Magnitude would weigh.* Therefore as all *Globes* deſigned for this Uſe are made of Wood, and notwithſtanding they are filled with an *Aquatic Compoſition*, are lighter than Water, they muſt (according to *Archimedes*) riſe in ſome proportion above the higheſt Surface of it; and that in ſuch degree, that the Part of the *Globe* which is immerſed, preſſes upon the Surface beneath, with a Preſſure equal to that of a Bulk of Water as big as itſelf. Thus the immerſed Part of a *Water-Globe* bears ſuch Proportion to the Whole of it, as the Weight of the

the entire *Water-Globe* does to a Bulk of Water equal to itſelf in Magnitude, and ſo on by an inverſe *Ratio.* Thus a Bulk of Water equal in Magnitude to the immerſed Part of the *Globe* is always equal in Weight to the Whole of it. As for Example; be there a *Water-Globe* whoſe Weight is 3 ℔, and let $\frac{3}{4}$ of it be immerſed in Water, and $\frac{1}{4}$ riſe above the higheſt Surface. I ſay, that in this Caſe the Weight of the whole *Water-Globe* is exceeded by that of a Bulk of Water equal to it in Magtude in the ſame Proportion as the immerſed Parts of it are by the Whole, namely by $\frac{1}{4}$; and thus a Bulk of Water equal to the *Water-Globe* muſt weigh 4 ℔. And by inverting the Propoſition, if the Weight of a Bulk of Water be well known, and if a *Ball* be immerſed in it to $\frac{3}{4}$ of its Height, it will be evident that ſuch a *Ball* or *Globe* will be $\frac{1}{4}$ lighter than ſuch a Bulk of Water. That is, that a Body of Water containing 3 of the 4 Parts of the *Ball*, will weigh as much as the whole *Ball.* Now if theſe 3 Parts of Water equal to the 3 Parts of the *Water-Globe* are called 3 ℔, we may ſafely conclude that the whole *Water-Globe* weighs 3 ℔ likewiſe. But we commonly contrive them in ſuch a manner as not only to ſwim upon the Surface of the Water, but likewiſe to be juſt even with the very Top of it, and ſometimes to be quite immerſed in it; that they may, by means of the *Fire* iſſuing from them, throw up the *Water*; and that the more the former is reſiſted by the latter, the more it may be enabled to oppoſe it, which is the great Point, and the only thing you are to endeavour at.

If now your *Water-Globes* are ſpecifically lighter than Water, they will not be totally immerſed in it, but will aſcend above the higheſt Surface in a certain Proportion; and as faſt as the *Fire* conſumes the *Compoſitions* in them, they will become ſtill lighter, and muſt neceſſarily riſe higher and higher till all is waſted. For this Reaſon it is neceſſary that your *Water-Globe* be of the ſame ſpecific Gravity with Water, to the end that the *Vertex* of it may be exactly level with the Surface of the Water: Or it may be a little heavier if you will, that it may be totally immerſed; which will be beſt for the Reaſon above given (namely) becauſe the ſucceſſive Conſumption of the *Compoſition* muſt naturally take away from the Firſt Weight of the *Water-Globe.*

Now that you may know the ſpecific Gravity of a *Water-Globe* with regard to Water, and conſequently that Part or Portion of it, that would aſcend above the higheſt Surface of the Water: And likewiſe that you may know, what Weight of Lead ought to be added to a *Water-Globe*, to make it *Æquiponderant* with Water, or a little heavier: As alſo how to find the ſpecific Gravity of Water with regard to your *Water-Globe*, without meaſuring or weighing either the *Water* or *Globe* by any ordinary *Mechanical* Contrivance; and that you may be perfectly well verſed in whatever relates to this matter; I ſhall illuſtrate the Whole in the plaineſt Manner, by a Calculation of the Firſt Sort of *Water-Globes* we deſcribed above.

We ſhall then ſuppoſe the *Axis* or Diameter of the ſaid *Globe* to be divided into 9 equal Parts, each of which we will take to be an *Uncia* of the *Rhynland* Foot; from whence we may eaſily come at its Solidity, and the Weight of a Wooden *Globe* made in that Form.

Let us range the *Analogy* as follows, *(viz.)* as 21 is to 11, ſo is the Cube of the Diameter of a *Globe* of 9 *Unciæ* (which is 729) to the Solidity of the *Globe* in Cubic *Unciæ* or Inches; according to the Demonſtrations of *Chriſtopher Clavius, Geomet. Prat. Lib.* V. Fol. 253. From this Operation you will have about 381 Cubic *Unciæ*, which would be the Contents of this *Globe* if it was Solid and Full; but as it is Hollow and Empty, and the Diameter of its Cavity is 7 *Unciæ*, we muſt find out the Contents of that Cavity in the ſame manner as if we ſuppoſed it to be Solid. Say then as 21 is to 11, ſo is the Cube of the Diameter of 7 *Unciæ* to the Capacity of the above-mentioned Cavity. Now the Cube of this Diameter being 343, the Capacity will be found to be 179 Cubic *Unciæ*, or thereabouts. This Capacity of the Hollow of the *Ball*, which is 179 *Unciæ*, being ſubſtracted from 381 the whole Contents of the *Globe* (which we at firſt ſuppoſed to be Solid) you will have a Remainder of 202 Cubic *Unciæ*, which are the Contents of the whole Shell of this *Globe*, whoſe Thickneſs throughout is one *Uncia*. To this muſt be added the Solidity of the Hemiſphere upon the Tompion which ſtops up the Orifice of the *Globe*; which you may find out after this Manner.

Double the Plane of the Baſe of the Hemiſphere, which ſhall be 3 *Unciæ* and $\frac{1}{2}$ ſquare, or 42 Lines, and being doubled, you will have 7 *Unciæ* ſquare or 84 Lines for the Convex Superficies. In ſhort, multiply this by $\frac{4}{7}$ of the Diameter of the Baſe of the Hemiſphere, and your Product will be 336 Lines for its Solidity, which are $\frac{1}{7}$ of an Inch and 48 Cubic Lines, which being added to the former Number will conſtitute a Body whoſe Solidity in Cubic Inches will be 202 *Unciæ* or *Inches* and $\frac{1}{7}$ and 48 Lines, or if you would have the whole reduced to Cubical Lines you will have 349392 of them.

You may again come at the Weight of this Body after this Manner. In the firſt Place ſuppoſe it to be made of Iron. Now according to the *Rule* laid down in Book I. Chap. VI. an Iron *Ball* whoſe Diameter is 4 *Unciæ* ought to weigh 8 ℔; therefore as the Cube of the Diameter of a *Ball* of 8 ℔ is to its Weight, ſo is the Cube of the Diameter of a *Water-Globe* to its own Weight if it was made of Iron. The Operation being over you will have 49 ℔, or thereabouts, for the Weight of the Shell if made of Iron: But as it is made of Wood, you muſt take the proportional Numbers of Iron and Wood from the *Table* Book I. Chap. IX, and ſay as 42 : 3 ſo is the Weight of Iron laſt found to the real Weight of the Wooden Shell or hollow *Globe*; from whence you will have 3 ℔, 8 *Ounces*, or thereabouts.

Let

Let the *Compoſition* which fills the Cavity of the *Globe* be here ſuppoſed to weigh 8 ℔, 10 *Ounces*, 2 *Deniers* and 7 *Grains*; and let the Weight of the Iron *Petard* or *Cracker* be called 4 *Ounces*; and let the *Powder* in it be one *Ounce*. Now add the Weight of the Wooden *Shell*, to that of the *Compoſition* and *Cracker*, and you will have in all 10 ℔, 11 *Ounc.* 7 *Dr.* 2 *Den.* and 12 *Gr.*

According to this ſame Method, you may find out the Weight of a Bulk of Water equal in bigneſs to your *Water-Globe*. We have ſaid in Chap. XII. of Book I, from the Teſtimony of the *Ancients*, that a Veſſel of a *Roman* Cubic Foot being filled with Water would weigh 80 ℔ Menſural, and but 66 ℔ 8 *Ounces* Ponderal. Farthermore, we have from the Obſervations of *Dogen* agreed, that the ancient *Roman* Foot was equal to what we call the *Rhynland Foot*; and therefore a Cubic *Rhynland* Foot of Water ought to contain as much in our Days as it did formerly: But as I have experienced that a Cubic Body of Water each of whoſe Sides is 6 *Unciæ* or half of the *Rhynland* Foot (the Water being taken out of the *Rhine* near *Leyden* in *Holland*) weighs about 8 ℔ 2 *Ounces* Ponderal of ours, each *Pound* 16 *Ounces*: It muſt follow, that as a Cubic Body whoſe Dimenſion is a Foot contains 8 of the aforementioned, it muſt weigh 65 ℔ of ours. And becauſe on the other hand a Cubical Foot containing 1728 Cubic Inches weighs alſo 65 ℔; 381 Cubic *Unciæ* or Inches, which are contained in a Bulk of Water equal to the *Water-Globe* we are now treating of, muſt weigh 14 ℔, 5 *Ounc.* 2 *Dr.* 1 *Den.* and 8 *Gr.* as may be eaſily ſeen by any one who will give himſelf the trouble of proving it.

Well; let us now compare theſe two Weights to one another (namely) that of the *Water-Globe* filled with a proper *Compoſition*, which is 10 ℔, 11 *Ounc.* 7 *Dr.* 2 *Den.* and 12 *Gr.* and that of a *Bulk* of *Water* equal in Magnitude to the aforeſaid *Water-Globe*; which we have found to be 14 ℔, 5 *Ounc.* 2 *Dr.* 1 *Den.* and 8 *Grains*; and by ſubſtracting the Leſſer of theſe from the Greater, we ſhall have a Remainder of 3 ℔, 9 *Oun.* 2 *Dr.* 1 *Den.* and 20 *Gr.* Now as this is exactly the $\frac{1}{4}$ Part of the aforeſaid *Bulk* of *Water*; we muſt conclude that the *Water-Globe* is $\frac{1}{4}$ lighter than the *Water*; and conſequently, that the $\frac{1}{4}$ of the *Water*, of equal Magnitude with $\frac{1}{4}$ of the *Water-Globe* will be as Heavy as the Whole of it.

Therefore if we would prepare a *Water-Globe*, ſo as to have it totally immerſed in Water without ſinking to the Bottom; and that the *Vertex* of the *Globe* ſhould be exactly upon a Level with the Surface of the *Water*; we muſt add a Counterpoiſe (as we have called it) whoſe Weight is equal to the difference of the two Weights above-mentioned (*viz.*) the $\frac{1}{4}$ Part of the Weight of the Bulk of Water, which is 3 ℔, 9 *Ounc.* 2 *Dr.* 1 *Den.* and 20 *Grains*; that is, you muſt tie a piece of Lead to it of that Weight, or elſe make a Cavity round the lower Tompion, and pour as much melted Lead into it as will ſupply that Difference.

ference. In ſhort, it would not be amiſs if you added a Weight ſomewhat ſuperior to the above-mentioned Difference, for ſeveral Reaſons which I have already given, and which it were needleſs to repeat here.

Now in order to find out that Point upon the *Axis* of a *Water-Globe*, together with a certain Circle deſcribed round it upon the Convexity of the ſaid *Globe*, through which if an Horizontal Plane paſs, it would cut off a Fourth of the *Water-Globe*; or to ſhew how deep it would be immerſed in Water if it was a Fourth lighter than Water; I ſay in order to find out this, you may proceed as follows.

Since according to *Luc. Valerius*, who ſpeaking of the Center of Gravity of Solids ſaith, *Lib.* II. *Prop.* 33. *Hemiſpherii Centrum gravitatis ſit punctum illud, in quo ſi Axis dividitur ut pars quæ ad verticem ſit ad reliquum ut* 5 *ad* 3. *That the Center of Gravity of an Hemiſphere is in that Point of the* Axis *through which if it was biſected, the upper Section of it would be to the lower as* 5 *is to* 3. Therefore you may divide the Semi-Diameter of a *Globe*, or the *Axis* of an Hemiſphere, into 8 equal Parts; and as each of them is compoſed of 6 $\frac{1}{4}$ Lines, ' of the *Axis* of the Hemiſphere, or 33 $\frac{3}{4}$ Lines, or 2 Inches, 9 Lines and $\frac{3}{4}$ meaſured upon the *Axis* from the *Vertex* of the Hemiſphere towards the Baſe will give you its Center of Gravity; through which if a Plane be produced parallel to the Horizon, it will divide the Hemiſphere into 2 *Æquiponderant* Parts; for it is properly called, *Centrum gravitatis uniuſcujuſque corporis*; or *the Center of Gravity of any Body whatſoever*, according to the Definition of *Guid. Ubaldus*, and other Mechanics. *Punctum intra extrave poſitum circa quod undique Partes æqualium momentorum conſiſtunt; ita ut ſi per tale Centrum, ducatur planum figuram quomodocunque ſecans, ſemper in partes æquiponderantes ipſam dividat. This Point, whether it be placed within or without, is That round which all the Parts of a Body are at reſt, and ſituated in ſuch a manner, that if a Plane be produced through that Center biſecting the Body in any direction whatſoever, it will be always divided into* æquiponderant *Parts.* Therefore the upper Section of the Hemiſphere is $\frac{1}{4}$ of the whole *Water-Globe.* And if from the Point laſt found on the *Axis* of any Hemiſphere, you upon any Plane deſcribe as from a Center a Circle whoſe *Radius* is equal to the upper Section of the *Axis*; and take the Circumference of ſuch a Circle with a piece of Thread, and tying the two Ends of it together, you apply it to the Convexity of the *Globe*, it will ſweep over that Portion of it as would be immerſed in Water, provided that ſuch *Globe* be $\frac{1}{4}$ lighter than a Bulk of Water equal to it in bigneſs.

To tell you now how to find out the *Aliquot* Parts of an *Integer*, with regard to other Bodies of Infinite Variety as to Figure, beſides ſuch as are regular or approach nearly to a Regularity, or to teach how to ſeparate them from the reſt of the Body; is neither my Intention, nor my Buſineſs in this Place. The curious *Pyroboliſt*, who would give himſelf

himſelf the trouble of learning it, may have recourſe to *Villalpandus*, *Tom.* III. *Par.* II. or *Kepler*'s *New Stereometry*, and the Works of many other *Geometricians* and *Mechanics*, who have written largely upon that Subject.

In ſhort, the ſpecific Gravity of Water, and the Weight of Bodies immerſed in it, may vary infinitely; and therefore we muſt retract what we ſaid of *Water* in Book I. Chap. XII. The firſt thing you are to ſeek after in all Caſes of this kind, is the Specific Gravity of the Water, without a Knowledge of which you may be liable to err. All that I have here ſaid to you is but by way of Example, and to mark out a Path which will infallibly conduct you into the High Road, which leads to ſo many wonderful Operations.

But before I lay down my Pen, I muſt add to all this, a Method for † weighing all ſorts of Bodies regular or irregular (for which it is chiefly deſigned) in Water; which will be as agreeable to our *Pyrotechnician* as it will be uſeful and neceſſary to him. I have taken it from *Merſennus*, and preſent it to you in his own Words, as you may find them in his *Phenom. Hydr. Prop.* 46.

What Archimedes *means by* Magnitude, *is* Body, *tho' it be empty Space that is merely a* Vacuum, *and containing no corporeal Subſtance: Whatever has* Extenſion, *may be ranked under that Denomination, even by thoſe who believe Space, (or who think there is a* Medium) *deſtitute of* Reſiſtance. *If now you ſuppoſe ſuch a void Space to deſcend in Water, the Water would riſe as much as if a Solid Body of the ſame Bulk had ſunk down into it: As for Example, a Veſſel being filled with Air only, and preſſed down into the Water, has the ſame Effect as if it had been filled with Water, or any other Liquid; ſo that if you ſuppoſe a Cubical Space which is perfectly deſtitute of Weight, to be forcibly immerſed and kept under Water, it would have the ſame Effect with reſpect to the Water as a Cube of Lead equal to it in* Extenſion, *allowing the Force requiſite to keep it under is equal to the Gravity of the Lead.*

But let us now proceed to conſider Solid Magnitude or ſuch as is Hard. Let there be for Example a Body lighter than Water, whoſe ‡ *Gravity may be eaſily found by a previous Knowledge of the Gravity of the Water, or any other Liquid it may be immerſed into, as alſo the immerſed, or emerſed Parts of it. Let then the Part immerſed be to the Whole of it as* 1 *to* 12, *and the Gravity of the Water will be to that of the Body as* 12 *to* 1: *And if the immerſed Part of the Body is but Subquadruple or Subduple of the whole, a Body of Water of the ſame Bulk with the whole Body would be* 4 *times or twice its Weight.*

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† He, by this, properly means a Method of finding out the Specific Gravity of any thing with reſpect to Water, and ſo on inverſely.

‡ He here all along means Specific Gravity.

You may by another way determine the Gravity of Bodies lighter than Water; (namely) by ſuperadding a Subſtance that is heavier than Water, ſuch as Lead whoſe Weight is known, and which by its Gravity immerges light Things; for it will be eaſy to conclude, that a Bulk of Water equal to them both, will be exactly the Difference of the Weight of thoſe Bodies in Air and in Water; by the Weight of which you may readily come at the Gravity of the Body lighter than Water, by this Method of reaſoning; (namely) That the Weight of a Body of Water equal in Bulk to the Lead being taken from the whole Maſs of the Water which is equal to both the Lead and the other Subſtance, there will remain a Weight of Water equal in Bulk to the lighteſt Body.

For Example; Let there be given a Wooden Stick or Cylinder whoſe Weight in the Air is 12 *Ounces, and be there ſuperadded to it* 11 *Ounces of Lead, and throw them into Water. I ſay, that as this Lead weighs but* 10 *Ounces in the Water, a Body of Water equal to it in Bulk would weigh one Ounce exactly. Now let us ſuppoſe the Weight of the one and the other immerſed Body to be* 16 *Ources whilſt in the Water, the Aggregate of whoſe Weight in the Air was* 23 *Ounces: The Difference between* 16 *and* 23 *being* 7, *it will give you to underſtand that a Maſs of Water equal in Bulk to the Wooden Cylinder and Leaden Weight would weigh* 7 *Ounces; from which if you ſubduct a Body of Water equal in Bulk to the Lead only, there will remain* 6 *Ounces for a Bulk of Water equal to the Wooden Stick or Cylinder. The ſame thing will happen, if you immerge ſeveral Bodies together that are lighter than a Liquid, by means of a Superaddition of Lead, or any thing elſe that is heavier than ſuch a Liquid.*

But care muſt be taken that the Body immerged doth not contract, or imbibe any of the Liquid in its Pores, by which means it would be heavier than it was when weighed in Air: Tho' this Accident may be eaſily prevented by coating the Body well over with Wax, Pitch, or any thing of that Nature; for by ſubſtracting a quantity of Water equal to the Wax, &c. *the Remainder will infallibly give you the Gravity of the Porous Body. But you muſt firſt weigh the Quantity of Wax or Pitch uſed in coating the Porous Body, whether it be of Wood, Stone,* &c. *and farthermore know the Specific Gravity of the Wax or Pitch with regard to Water.*

As for Example; ſuppoſe the Wax uſed in coating the Body weighs 22 *Ounces in the Air, a Bulk of Water equal to it will infallibly weigh* 21 *Ounces; therefore muſt you ſubduct a Bulk of Water of* 21 *Ounces, if you would by the Weight of the Remainder of the Bulk equal to the Body, know the Specific Gravity of the Body itſelf, as we have already ſaid.*

If you would know any thing farther relating to this Matter, conſult the ſame Author in the ſame Treatiſe, *Prop.* 43, 44, 45, 47, and others, which will ſatisfy you upon this Head. If theſe ſhould not be ſufficient, you may have recourſe to *Galileus*, who ſpeaks clearly on this Subject; and beſides them, you have a little *Italian* Book publiſhed by

by *Nicolas Tartaglia*, intitled, *Ragionamenti de* Nicolao Tartaglia: *Sopra la ſua travagliata Inventione.* With another intitled, *Regola generale da ſulevar é miſurar non ſolamente ogni offendata nave: ma una torre ſolida, di metallo trovata da* Nicolao Tartaglia.

CHAP. II.

Of Recreative Globes *that leap and bound upon* Horizontal Planes.

SORT I.

TAKE an hollow Wooden *Globe*, perfectly Round, with its Orifice and Tompion, in the ſame Proportion and Form as we directed for the firſt Sort of *Water-Globes* in the foregoing Chapter; and fill it with an *Aquatic Compoſition.* Then be there 4 Iron *Petards* or *Crackers* (or more if you will) made in the Form you ſee in *Fig.* 93 under the Letters A, B, C, D: Theſe you ſhall fill with the beſt *Corn Powder* you have, and ſtop them up with Wadds of Paper or Tow. Then boring Holes in your *Globe* of a proper Size to receive your *Petards*, you ſhall ſecure them with Nails to the Outſide of your *Globe*; which done, you will have the Whole prepared. If you fire this upon a ſmooth even Spot, you will ſee it leap, and bound, as often as the *Petards* in it go off. Fig. 93.

SORT II.

Get a ſolid Wooden *Ball* made as Round as poſſible, and coat it well over with Wax. Then cut long Slips of Paper of the Breadth of 2 or 3 Inches, and paſte them to the Convexity of your *Globe*, ſo that it may be entirely covered with them, but not with one Layer only, but to the Thickneſs of one or two Lines: Or what will be more expeditious, Take of that Pulp or Paſte of which Paper is made, and diſſolve it in Glue Water, and with it coat over the whole *Globe*, and dry it by a very ſlow moderate *Fire*; and being perfectly dried, divide it into two Parts. In ſhort, ſet it then before a *Fire* which is hot enough to melt the Wax, and you will have two hollow Paper Hemiſpheres (as you may readily conceive) with which you ſhall make a Leaping or Running *Ball*, after this Manner. Take three common *Rockets* filled and bored, as we directed for the Firſt Sort of *Sky-Rockets*, excepting only the *Report* which is not here neceſſary. Theſe *Rockets* ſhall be of ſuch Length as not to exceed the interior Diameter of the Hemiſphere. Fix then theſe *Rockets* in either of the Hemiſpheres, and diſpoſe of them ſo as Fig. 94.

that they may have their Heads and Choaks alternately even with each other: And thus they muſt be ordered; that when the Firſt is quite ſpent, the Second may immediately take Fire, and force the Hemiſphere back again; and ſo on with the Third, when the *Fire* is communicated to that. Care however muſt be taken, that the *Fire* does not privately paſs from the Firſt *Rocket* to the Second or Third, before it is quite conſumed: This Danger you may eaſily avoid, if you keep in Mind, what we have already ſaid of two *Rockets* joined together, when we treated of thoſe that run upon Ropes. Now in order to fire this *Globe* you ſhall make an Hole in your Paper Hemiſphere over-againſt the Choak of the Firſt *Rocket*. In ſhort, all the neceſſary Precautions being taken in fixing your *Rockets*, you ſhall cover them with the other Hemiſphere, which ſhall be firmly joined to the Firſt with ſtrong Paſted Paper; you muſt be careful in doing this, for fear leſt in turning, running, and winding about, they ſhould be torn from each other; whereby your Labour and Expence might become matter of Laughter to the Spectators, and yourſelf be put to Confuſion inſtead of meeting with Applauſe. In a Word; ſuppoſing them to be well joined together, ſet fire to the Priming which correſponds with the Firſt *Rocket*, and leaving it freely upon an even Horizontal Plane, you will ſee it run and fly about with ſuch Swiftneſs, and with ſo extraordinary a Motion, as will ſurprize the Beholders. In the ſame *Scenographical Figure*, the Letters A B C ſhew the *Rockets*, and how they muſt be fixed in the Hemiſphere.

SORT III.

This *Globe* is not very unlike the Firſt Sort, excepting that to this you add a certain Number of *Crackers*, which are diſpoſed as you may ſee Fig. 95. in *Fig.* 95, where the *Crackers* are diſtinguiſhed by the Letter A, and the *Vent* or Touch-hole by B.

CHAP.

CHAP. III.

Of Recreative Aerial Globes *which are projected from a* Mortar-Piece.

WHEN you would make any of theſe *Aerial Globes*, which are thrown up into the Air by *Mortars*, you ſhall firſt of all take care to have the *Calibre* of the *Mortar* you intend to uſe: And having found it, you ſhall divide it into 12 Parts, one of which you ſhall allow for the Windage of the *Globe*, and $\frac{11}{12}$ ſhall remain for the Diameter of the *Globe* you intend to make. You ſhall then divide this Dia- Fig. 96. meter into 6 equal Parts; and the Height between A and C ſhall be equal to the Diameter of the *Globe*; the *Radius* of the Semi-Circle C I ſhall be $\frac{1}{6}$ or half of the Height or Breadth of the *Globe*. The Thickneſs of the Wood H I ſhall be $\frac{1}{12}$ of the above Diameter; but the Thickneſs of the Cover A K ſhall be $\frac{1}{6}$ of the Diameter of the *Globe*. The Diameter of the Cavity G H of this *Globe* ſhall be $\frac{1}{4}$ of its whole Diameter. The Height of the Priming-Chamber B F ſhall be $\frac{1}{6}$ and $\frac{1}{3}$ of the Diameter; but its Breadth $\frac{1}{6}$ only; that is, its Height ſhall be 1 $\frac{1}{2}$ of its Breadth. As for the Diameter of the Touch-Hole, it will be ſufficient if it is $\frac{1}{4}$ or $\frac{1}{5}$ of that of the Chamber.

This is all I can ſay of the Proportions of this Sort of *Balls*, as to their Wooden Conſtruction: But as for the Manner of filling them, the following Directions will fully inſtruct you. The Figure of this *Globe*, and thoſe which follow it, may be plainly underſtood by *Fig.* 96.

Obſerve here, that the Proportions of theſe *Globes* are only to be underſtood of thoſe which are projected from great *Mortars* (namely) ſuch as can carry a *Stone Ball* of 30, 40, 60, or 100 lb, or more if you can get any ſuch: But for the Leſſer, which carry but 6, 10, 15, or 20 lb of *Stone*, theſe *Globes* may be made of Paſted Paper, and rowled in faſhion of a Cylinder, excepting only the Bottom which ſhall be of Wood, as well as their Priming-Chambers and Vent-holes.

SORT I.

Take hollow Canes or common Reeds, and cut them into Lengths to fit the Cavity of the *Globe*, and fill them with a *ſlow Compoſition* made 3 Parts of *Meal Powder*, 2 of *Coal*, and one of *Sulphur*, moiſtened with a little *Oil* of *Petrol*; excepting the lower Ends of them which reſt upon the Bottom of the *Globe*, which ſhall have *Meal Powder* only, moiſtened in like manner with *Oil* of *Petrol*, or ſprinkled over with *Brandy*, and then

then dried, to make them take *Fire* the better. You ſhall moreover cover the Bottom of the *Globe* with *Meal Powder* mix'd with an equal quantity of that in *Corns*. Theſe Reeds being filled after this manner, you ſhall ſet as many of them upright in the Cavity of the *Globe* as it is capable of containing. Then cover it well at Top, and wrap it well round, with a Cloth dipped in Glue, or any tenacious Subſtance. The Priming ſhall be of the ſame *Compoſition* with the Reeds, or one of the two following. The Firſt; made of 8 Parts of *Powder*, 4 of *Saltpeter*, 2 of *Sulphur*, and one of *Coal*. The Second; 4 Parts of *Powder*, and 2 of *Coal*. Meal, mix, and incorporate theſe *Ingredients* together as well as poſſible. To conclude, you ſhall ſtick round the Orifice or upon it (with a little *Pyrotechnic* Glue, which we ſhall ſpeak of in the following Book) ſome *Quick-Match* (which muſt be prepared as we directed in Book II. Chap. XXIX.) with ſome untwiſted Tow of the
Fig. 96. ſame ſort. *Fig.* 96 ſhews you the whole of this; for the Letter L points out the Reeds contained in the *Globe*. The reſt needs no Explanation.

SORTS II and III.

Fig. 97, and 98. Theſe two Sorts of *Recreative Globes*, which you ſee repreſented under *Figures* 97 and 98, are perfectly contrived like the Firſt Sort, with only this Difference between them, that the Firſt of theſe is filled with *Running Rockets*; and the Laſt with *Paper Crackers* and *Stars*, and *Pyrotechnic Sparks* interſperſed with *Meal Powder*, which are put promiſcuouſly over the *Crackers*. It is needleſs then to dwell any longer upon theſe, ſince you may gather whatever relates to them, from what I have ſaid above, as alſo from the Repreſentations of them; which are ſo plain, that it is impoſſible for any Body to be miſtaken that does but conſider them a little.

SORT IV.

This *Globe*, which we rank in the Fourth Place, and which we have
Fig. 99. repreſented in *Fig.* 99, is not ſo difficult in its Conſtruction, but that it may be eaſily comprehended by the *Figure* itſelf. Firſt of all, the Great *Globe* which contains a Leſſer in it, is the very ſame with thoſe above-deſcribed; for it is charged with *Running Rockets* as well as that of the Second Sort: But however with this Difference, that this is lined but with a ſingle Range of *Rockets*, as may be ſeen in the Letter A; whereas the Cavity of the other is quite filled up with them. In the midſt of theſe *Rockets*, you fix a *Globe* in a Cylindrical Form with a flat Bottom as B, and a Chamber and Touch-hole at D. The Capacity of this Inner *Globe* is filled with *Iron Crackers* as C, and covered with a flat Covering as E. You ſhall fill the Priming-Chambers with the ſame *Com-*

poſition

poſition as we have ordered for the above *Globes*. As for the Fuzes they ſhall be of good *Meal Powder*.

SORT V.

As for the Conſtruction of this Fifth Sort of *Recreative Globes*; it differs in nothing from the Fourth above deſcribed, except that it is larger and more capacious, and contains two others one within another. The Biggeſt of all is diſtinguiſhed by the Letter A, which is charged with Tubes D; (the Conſtruction of which we have ſo often given) whoſe Orifices are all turned downwards, upon the Bottom of the *Globe*, which is ſpread over with *Corn* and *Meal Powder* mixed together. The Second and Middlemoſt, diſtinguiſhed by B, is in like manner charged with one Row or Round of *Running Rockets* E. In ſhort, the Third and Smalleſt *Ball* C is charged with other ſmaller *Rockets* as may be ſeen in F; in the Middle of which is a *Light Ball* G. As for any thing farther relating to it, you are to proceed in the ſame Manner as was ordered with regard to the aforementioned Sorts; ſee the Repreſentation of this *Fig.* 100, which will illuſtrate it, if our Explanation is any way defective. Fig. 100.

SORT VI.

Firſt get a Wooden *Globe*, in the Middle of which let there be made a *Mortar*, with a little Chamber for *Powder*; round which ſhall be formed a *Berm* or *Ledge*, for the conveniently ranging of certain Paper Tubes or Caſes: In this *Berm* you muſt hollow out a little Groove or Channel, which muſt be filled with *Meal Powder*, for conveying the *Fire* all round. This done, you ſhall put a *Recreative Globe* into the *Mortar*, filled with *Running Rockets*, *Paper* or *Iron Crackers*, *Reeds*, or in ſhort, with *Stars* and *Sparks* which we have ſo amply deſcribed elſewhere. Upon the aboveſaid Channel then, you ſhall place your Caſes or Paper Tubes, exactly after the Manner we ordered in the foregoing Chapter for the Sixth Sort of *Water-Globes*, which ſhall be filled with *Running Rockets*, and covered round with ſtrong paſted Paper or Glued Cloth. Caſt your Eye upon *Fig.* 101, where the Letter A points out the Wooden *Globe* without any Addition to it. The Letter A alſo ſhews its *Mortar*. E the Hollow in the *Berm*. D the Touch-hole. C the Priming-Chamber, and B is the Chamber of the *Mortar*. But in the other *Figure* diſtinguiſhed by B, the Letter F ſhews you the Order in which your Paper Caſes ought to be placed upon the hollowed *Berm* or *Ledge*. The reſt may be readily comprehended by whoſoever rightly conſiders this *Fig.* 101. Fig. 101.

SORT VII.

You ſhall order a Wooden *Globe* to be made whoſe Height is double
Fig. 102. of its Breadth; ſuch as you ſee in *Fig.* 102, where its Height from A to B, is double of its Breadth from C to D. So much for its outward Form. Hollow out one half of it (I mean the upper Part) after the ſame Manner as has been done with regard to the preceding *Recreative Globes*; which Cavity ſhall be filled with *Running Rockets* or *Crackers*, or ſome other of thoſe Things we have mentioned above. Then clap a Cover over it. The Lower Part of this *Globe* ſhall have a Priming-Chamber at E, whoſe Height and Breadth ſhall be $\frac{1}{6}$ of the Diameter of the whole *Globe*; and the Touch-hole ſhall be $\frac{1}{5}$ or $\frac{1}{4}$ of it. This done, you ſhall pierce all the Lower Part of the *Globe* with Cavities which ſhall not be ſo deep as to interfere with the Touch-hole in the Middle; but between the Inner Extremities of them and that, there ſhall be the Thickneſs of half an Inch of Solid Wood: Which however ſhall be afterwards bored with a red-hot Iron, ſo as to have a Communication with the Touch-hole. You may ſee how this is to be done by the Letters G and F. Theſe Cavities ſhall be of ſufficient Capacity to receive *Iron Crackers* or *Running Rockets*. Now to repeat to you, how they ought to be fixed; what ought to be obſerved to make them depart after they are lighted; or what muſt be done or not done to procure the deſired Effect from them; this is what I have ſo often touched upon, that a farther Repetition might be troubleſome. Let us then proceed to the following Sort.

SORT VIII.

The Structure of this *Globe* is not ſo conſiderable on the ſcore of its Contrivance, as it is admired by the Spectators for its fine and agreeable Effects in the Air; and I may ſafely ſay, there are but few *Pyroboliſts* who can repreſent in the Air, in a dark cloudy Night, Letters or Cyphers in *Fire*, or whole Names, or even ſeveral Sentences all in *Flame*. Here then in the Conſtruction of this *Globe* (which I myſelf invented, and have often put in Practice) I intend to ſhew you one of this Nature, which will have ſuch Effects as cannot but be admired: In the ordering of which you muſt proceed as follows. In the firſt Place get a Wooden *Globe* of the ſame Form, and of the ſame Height, Breadth and Thickneſs, with that of the Firſt of this Sort of *Globes*, or of the ſubſequent of them, no matter which. Now the Priming-Chamber A,
Fig. 103. in *Fig.* 103, ſhall have its Breadth and Height of $\frac{1}{6}$ of the Diameter of the whole *Globe*. Beſides this Chamber you ſhall have another to receive *Corn Powder*, whoſe Height C D ſhall be equal to its Breadth D E, which ſhall be alſo $\frac{1}{6}$ of the Diameter of the whole *Globe*; but the

Fuze

Fuze or Vent-hole B ſhall have its Breadth one fourth of the Powder-Chamber, or Priming-Chamber above mentioned. You ſhall have alſo another *Globe* in a Cylindrical Form, the Bottom of which ſhall be rounded on the Outſide, as may be obſerved in the ſame *Figure* by the Letter F. The Cover of it, G, ſhall be let a little into the Inner Surface of the Cover of the Great *Globe*, in order to keep it firm; and this Leſſer *Globe* ſhall be placed perpendicularly over the Chamber which is filled with *Corn Powder*. You ſhall then fill the Cavity of this little *Globe* with *Running Rockets*, *Stars* and *Sparks*, as may be ſeen by the *Profil*. To the rounded Bottom of this *Globe*, ſhall be tightly fitted a Wooden Ring (the *Profil* of which you have in H;) the Subſtance of which ſhall be bored through with Holes, as you may ſee in I; or if you will, it may be fluted all round, as may be ſeen in K; or finally, you ſhall plant ſmall Iron Nails all round the Bottom of the *Globe*, in ſuch manner that their Heads may be all even, and form a perfect Circle, whoſe Diameter exactly correſponds with the Inner Diameter of the *Globe*, and its Circumference with the Circumference of the ſame. See it repreſented in *Fig.* L. After having prepared your *Globe* after this manner, take two long thin Slips of Whalebone (which the *Germans* call *Walfiſchbein)* which naturally permitting itſelf to be bent without any danger of breaking, and inclining to a voluntary Recurvature, it is very proper for the Uſe we ſhall here apply it to. You ſhall then take two Slips of it, which though rowled up in a Spiral Direction, have Strength and Spring enough to recover their firſt Rectitude, upon their being releaſed from their Conſtraint. Having two ſuch pieces of Whalebone join them together, diſpoſing of them ſo that their Convexities may be Inward, and their Concavities Outward, as may be plainly ſeen by M. Of theſe two curved Slips, you ſhall make one ſtrait Piece as N by tying them down at the Ends and in the Middle: Theſe Slips thus joined together, though bent and rowled up after any manner whatſoever, will by their own natural Spring and Energy recover their Rectitude, when left at liberty.

Take two Pieces thus prepared, and lay them Parallel to each other (conſider here the *Figure* O compoſed of thoſe Artificial Characters which expreſs *Vive le Roy)* and to the Extremities of them tie two ſhorter Pieces at right Angles with them; ſo as to conſtitute the right-angled Parallelogram P T S Q. Theſe four Pieces being thus bound together, you ſhall form the Letters or Cyphers within them, which ſhall be made of Lattin or Iron Wyre, or (what will be much better) of pieces of Whalebone; but your Letters, *&c.* muſt be of ſuch Size as not to exceed the Height of the Cavity H R, and if they are ſomewhat ſhorter it will be ſo much the better, as we have ordered it in our Example. Again; your Letters ſhall be at the Diſtance of a Palm from each other, or a Foot at moſt: In a Word, their Diſtances ſhall be according to the Capacity of the *Globe* you intend to

put

put them into. Your Letters being thus fixed in your Frame (or Parallelogram) take looſe Pyrotechnic or Quick Tow (prepared as we directed in Chap XXIX. of Book II.) and wrap them neatly round with it from one end to the other; then ſteep them in Brandy, in which you ſhall have previouſly diſſolved a little Gum *Arabic* or Gum *Dragant*, and as you dry them ſalt them over with *Meal Powder*. You muſt however take care that the pieces of Whalebone which form your Frame, are no ways incommoded or intangled by your Tow; for fear when your Letters burn out, their Flame ſhould be confounded in one another, and become indiſtinct in the Air. If now you would have your Letters deſcend perpendicular to the Horizon, you ſhall faſten two ſmall Weights to your Frame at S and Q only; but if you would have your Frame fall down parallel to the Plane of the Horizon, there ſhall be two other Weights at P and T; that is, there ſhall be a Weight at each Angle of your Parallelogram or Frame. Finally, the Whole being thus ordered, bend it round to go into the Inner Circumference of your great *Globe*; and let it reſt perpendicularly upon H in the aforeſaid *Globe*, and then fill up the empty Spaces between the Letters with *Meal Powder*. This done, cover it up, and I aſſure you nothing can be more delightful to the Sight, and that you will receive an unſpeakable Pleaſure from the Effects of this *Globe*; provided that in the Conſtruction of it you obſerve every thing that is here directed.

You may by a Contrivance of this Kind not only repreſent Letters and Cyphers in *Fire*; but alſo the Arms of Princes and great Lords, together with Human Figures, and Animals, which will move to and fro in the Air, to the great Satisfaction of the Beholders. But you muſt know, that to ſucceed in ſuch fine and difficult Attempts, it requires a Perſon to be poſſeſſed of a pretty good ſhare of Senſe, and ſound Judgment, joined to a perfect Knowledge in *Pyrotechnics*, and a fine Taſte of every thing relating to it: And where theſe Qualifications are wanting, I would adviſe no Body to engage themſelves in ſuch a Work; for neither *Æſculapius* nor all his Succeſſors of the Faculty, can find one Remedy throughout the whole Extent of their *Science* to repair the leaſt Miſhap that might befal you in this Caſe.

COROLLARY I.

Of Shining *or* Light-Balls, *ſuch as are commonly uſed at* Bonfires, *which the* Germans *call* Lichtkugel.

THERE are two Sorts of *Light-Balls* (namely) the *Recreative* and *Serious*; of the Laſt of which we ſhall ſpeak in its proper Place; and ſhall now only curſorily touch upon the *Recreative Sort*.

Take

Take of *Crude Antimony* 2 ℔, of *Saltpeter* 4 ℔, of *Sulphur* 6 ℔, of *Colophone* 4 ℔, and of *Coal* 4 ℔.

Or elſe; take of *Antimony* ℔ ſs, of *Saltpeter* j ℔, of *Sulphur* ℔ ſs, of *Colophone* j ℔, of *Coal* j ℔, and of *Black Pitch* ℔ ſs.

You ſhall put either of theſe *Compoſitions* (after having been well mealed) into a Braſs Boiler, or into any glazed Earthen Pot, and melt them over a Fire. Then throw as much Hemp or Flax into them as may be ſufficient to abſorb them quite up: And whilſt cooling, you ſhall make them up in *Balls* of ſuch Sizes as you want. Then wrapping them well up, and coating them with Pyrotechnic or Quick Tow; you may put them into *Rockets* or *Recreative Globes*, whether *Aquatic* or *Aerial*.

COROLLARY II.

Of Pyrotechnic Stars *and* Sparks, *called by the Germans* Stern-veuer *and* Veuerputzen.

PYROTECHNIC Stars differ thus much from the *Sparks*, that they are a great deal larger, and not ſo ſoon conſumed; but ſubſiſt in the Air, and ſhine out with a longer Duration, and with a Splendor which becauſe of its extreme Brightneſs, may in ſome degree be compared with the real *Stars* which adorn the *Firmament*. They are to be prepared after the following Manner.

Take of *Saltpeter* ℔ ſs, of *Sulphur* ℥ ij, of Powder of *Yellow Amber* ℥ j, of *Crude Antimony* ℥ j, of *Meal Powder* ℥ iij.

Or elſe; take of *Sulphur* ℥ ij ſs, of *Saltpeter* ℥ iiiiij, of *Powder* finely mealed ℥ iiiij, of *Olibanum* or *Frankincenſe* in Drops of *Maſtic*, of *Chryſtal*, of *Mercury Sublimate*, of each ℥ iiij, of *White Amber* ℥ j, of *Camphire* ℥ j, and of *Antimony* and *Orpiment* of each ℥ ſs.

All theſe *Ingredients* being well beaten and paſſed through a Searce, they ſhall be ſprinkled over with a little Glue Water, or Water of Gum *Arabic* or *Dragant*: Then made into little Balls of the Bigneſs of a Bean or ſmall Nut; and being dried by the Sun or Fire, they ſhall be laid up in ſome convenient Place, to be uſed in the *Artificial Fireworks*, which we have here ſo amply treated of. When you put them into *Rockets* or *Recreative Globes* they muſt be wrapped up in *Quick Tow*. *Pyroboliſts* ſometimes inſtead of theſe *Balls* take certain Quantities of a melted Stuff (which we ſhall ſpeak of hereafter when we teach you the Preparation of *Fire Rain*) which they wrap up in *Quick Tow* for ſeveral Uſes in *Fireworks*.

But if theſe do not pleaſe you becauſe of their blackiſh Caſt, and if you would rather chooſe to have them Yellowiſh or inclining to White;

Take ℥ iiij of *Gum Dragant*, or of *Gum Arabic*, beaten, mealed and paſſed through a Searce; of *Camphire* diſſolved in *Brandy* ℥ ij, of *Saltpeter* ℔ j ſs, of *Sulphur* ℔ ſs, of coarſe *Powder* of *Glaſs* ℥ iiij, of *White Amber* ℥ j ſs, of *Orpiment* ℥ ij: Incorporate all theſe *Ingredients* together, and make *Balls* of them as before. I learned this of *Claud Midorge*.

The Method of making *Sparks* is as follows: Take of *Saltpeter* ℥ j, of the ſame melted ℥ ſs, of *Meal Powder* ℥ ſs, of *Camphire* ℥ ij. After having mealed theſe *Ingredients* (ſuch as want it) apart, put them all together in an Earthen Pot, and pour upon them Water of *Gum Dragant*, or *Brandy* that has had *Gum Dragant* or *Gum Arabic* diſſolved in it, that the Whole may have the Conſiſtence of a pretty Denſe Liquid. This done, take an Ounce of Lint, or the Down of Linnen, which has been previouſly boiled in *Brandy*, *Vinegar*, or *Saltpeter*, then dried and ſpread out, and throwing it into this *Compoſition*, mix and ſtir it about, till it has abſorbed it all. This done, rowl it up in Pills about as big as a great Pea, which you ſhall ſet to dry after having ſalted them with *Meal Powder*. Uſe theſe according to our Directions.

We have, farthermore, a Way of preparing certain *Odoriferous Pills*, which are uſed in little *Pyrotechnical Machines* and Contrivances, which are fired in Rooms and Cloſets. Theſe are commonly compoſed of *Storax Calamita*, of *Benjamin*, of *Gum Juniper*, of each ℥ ij; of *Olibanum*, of *Maſtic*, of *Frankincenſe*, of *White Amber*, of *Yellow Amber*, and of *Camphire*, each ℥ j; of *Saltpeter* ℥ iij, of *Lime-Tree Coal* ℥ iiij. Theſe *Ingredients* are to be well beaten, pulverized and incorporated together; then moiſtened with *Roſe Water*, in which has been previouſly diſſolved ſome *Gum Arabic* or *Dragant*, that the Whole may be made up in Pills, which muſt be dried in the Sun or before a Fire.

COROLLARY III.

Of the moſt certain Method for Projecting Recreative Globes *from a* Mortar: *Of the Quantity of* Powder *requiſite for that Purpoſe: And of the* Chambers *to receive it.*

YOU muſt conſider that all theſe *Recreative Globes* are uſually thrown up into the Air in a Vertical Line, or againſt the Perpendicular of the Horizon; wherefore it is neceſſary that you ſhould have a thorough Knowledge of the due Quantity of *Powder* requiſite to diſlodge your *Globe*, and to project it into the Air to any determinate Height you would have it. We may come at this by two Ways. The Firſt is thus:

Weigh

Weigh your *Globe* with a Balance or Steelyard, and for every Pound that it weighs allow $\frac{1}{4}$ of an Ounce of *Gun-powder*. As for Example; if your *Recreative Globe* weighs 40 ℔, you muſt, to diſlodge it, allow $40 - \frac{1}{4}$ of an Ounce, or 10 Ounces of *Powder*: And this will be full enough for the purpoſe; for theſe *Globes* being made of Wood only, they could not bear the violent Shock of a larger Quantity; add to which, that the *Powder* confined in *Warlike Machines* exerts itſelf more to throw up a Body in a Right Line, than to project it in any Oblique Direction; becauſe it is proportionably more oppreſſed by the ſuperincumbent Weight, and has its Liberty thereby more reſtrained. This I ſhall endeavour to demonſtrate more amply elſewhere. If you ſhould be in a Place where no ſuch thing as a Balance or Steelyard is to be got; take the Diameter of your *Globe* with a pair of common Compaſſes, or with a pair of the crooked Sort, and apply it to that Side of the *Calibre Scale* calculated for Stone Bullets, and divide the Number to which your Compaſſes extend into two Parts, and you will have the Number of *Loths* or *half Ounces* of *Powder* requiſite to diſlodge your *Globe*.

Now ſuppoſe you do know the due Portion of *Powder* requiſite to project your *Globe*, yet methinks this is not enough; for you ought to know alſo, how and in what Form this *Powder* ought to be put into the *Mortar*. We have two Ways of coming at this. The Firſt of which: Be there made a certain Body of ſoft yielding Wood, in the Form of a truncated Cone reverſed, (which the *Germans* call *Setz-Kamer)* equal in Height and Breadth to the Chamber of the *Mortar*, in which ſhall be hollowed out a Chamber for receiving the *Powder*. This ſhall be pierced with a fine Borer, or a red-hot Iron Needle from the bottom of the Wood to the Center of the bottom of the Chamber in it; but not in a perpendicular Direction, but diagonally or ſlanting as from c to d in *Fig.* A under 104. The place where this Touch-hole begins ſhall be marked, ſo that when you fill the Chamber, it may be turned to correſpond with the Vent-hole of the *Mortar*. When therefore you would load your *Mortar* with a *Recreative Globe*, cover the Bottom of the Chamber with a little *Meal* and *Corn Powder* mixed together, and upon that put your Wooden Chamber, in which ſhall be the Quantity of *Powder* requiſite to project your *Globe*. In ſhort, your *Globe* ſhall have its Orifice turned down upon the *Powder*, and ſhall be wrapped round with Hemp or Flax, Hay or Straw, no matter what, ſo that it be not any thing that will retard its Flight, and hinder its Projection. Conſult *Figure* 104, which will give you a perfect Idea of all this. Fig. 104.

Obſerve here, that your Wooden Chamber ought to be of a Capacity ſufficient to hold all the Requiſite of *Powder*, and on the contrary, it ſhall not be ſo big as not to be entirely filled by it.

If by chance the Chamber of your *Mortar* is broader than needful, or if its Height is not well proportioned to its Breadth; or in ſhort, if

the

the Requiſite of *Powder* is ſo little as not to fill up the Chamber; (which may frequently happen, inaſmuch as *Recreative Globes* are much lighter than *Grenado's* or *Bombs*, &c. for which *Mortars* were chiefly deſigned; which have accordingly ſpacious Chambers to receive the Requiſite of *Powder* neceſſary to project thoſe heavy Bodies, and notwithſtanding you may make according to our firſt Method a Chamber that is juſt ſufficient to contain the Requiſite of *Powder*; yet as in ſuch a Chamber the *Powder* is not cloſely united, but is rather extended too much, it will not be ſo vigorous, nor act with ſuch Force upon the ſuperincumbent Weight, as if it was confined to ſome Chamber whoſe Cavity is proportioned to the Effect required; for the Reaſons here-under given) and therefore it will be neceſſary to have ſome Wooden Cylinder equal in Height and Breadth to the Chamber of the *Mortar*; in the Middle of which ſhall be bored a Cavity, whoſe Height is equal to that of the Chamber of the *Mortar* to hold the Quantity of *Powder* neceſſary to throw up the *Recreative Globe*. Now this may be done as follows.

Firſt, by a Scale divided into equal Parts, meaſure the Height of the *Powder* contained in the Chamber of the *Mortar* that is requiſite to project your *Globe*; and then by the ſame Scale meaſure the whole Height and Breadth of the Chamber. Then find out a mean Proportional between the Height of the *Powder* in the Chamber and the Height of the whole Chamber itſelf. This mean Proportional being found, you ſhall look out for a Fourth Proportional; by ſaying, As the mean Proportional found, is to the Height of the *Powder* in the Chamber, ſo is the Breadth of the Chamber to a Fourth Number. Having performed this after the common Way you will have a Fourth Proportional, which will be the Diameter of the future Chamber, capable of containing your due Requiſite of *Powder*, which Diameter you ſhall meaſure by the above Scale. This will be readily apprehended by the following Example.

Fig. 104. Let then the Chamber of your *Mortar* be a, d, in *Fig.* 104 under the Letter B, and let the Height of it be a c or b d; let the Height of the *Powder* in the Chamber be c e: Thus d e will be the Cylinder that contains a Quantity of *Powder* requiſite to project your *Recreative Globe*. As this *Powder* is not ſufficient to fill up the whole Chamber, there muſt of neceſſity be a vacant Space between it and the *Globe*, which reſts upon the Orifice of the Chamber. Now ſince, ſo large a Vacancy may be a great Hindrance to the Ejaculation of the *Globe*, and ſince the *Powder* is but a very little Quantity when compared with the Capacity of the Chamber; therefore muſt this Cylinder or Chamber which now contains it, be transformed and altered, into another equally capacious to it, and whoſe Height ſhall be at the ſame time equal to the whole Height of the Chamber of the *Mortar*. This is to be done after the following Manner.

Find

Fig. 89.

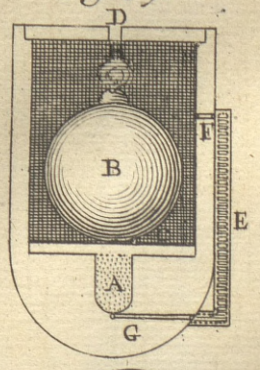


Fig. 90.

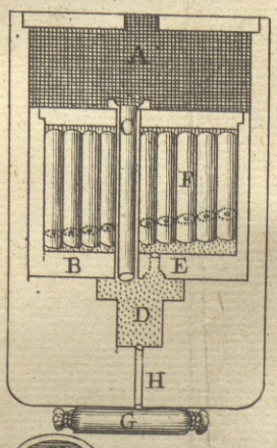


Fig. 91.

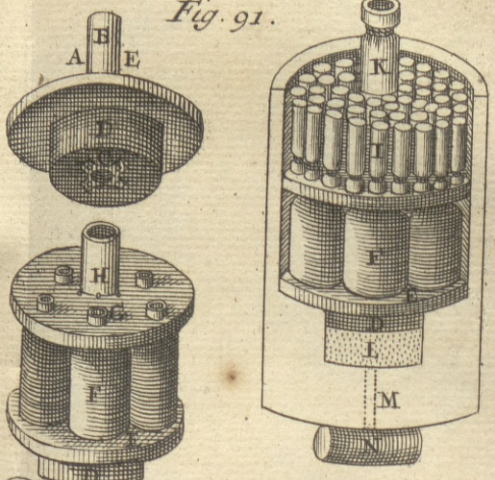
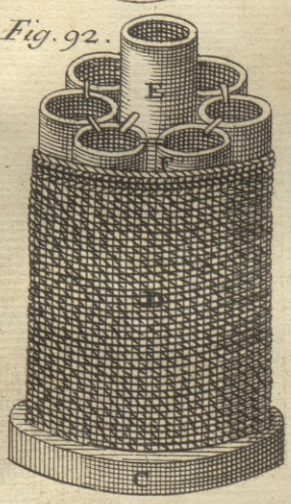


Fig. 92.



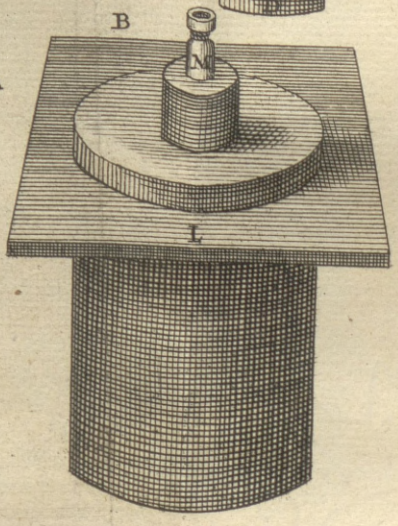


Fig. 93.

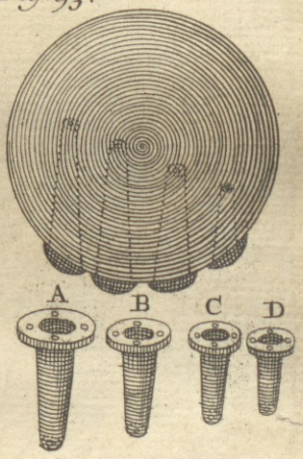


Fig. 94.

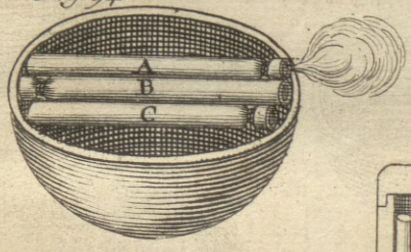


Fig. 95.

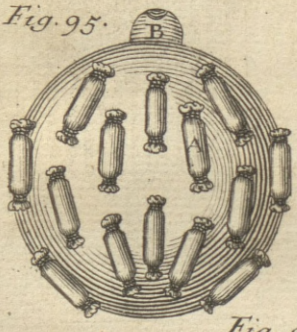


Fig. 96.

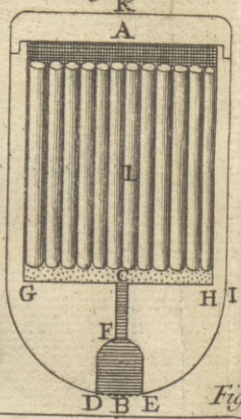


Fig. 97.

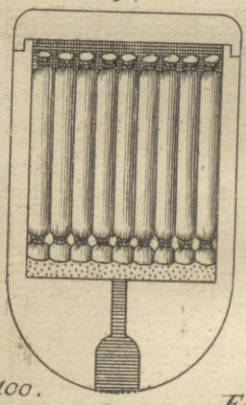


Fig. 98.

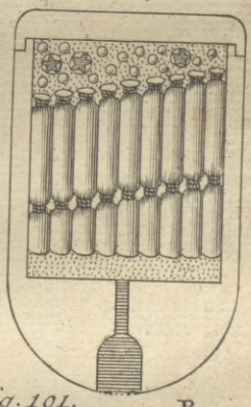
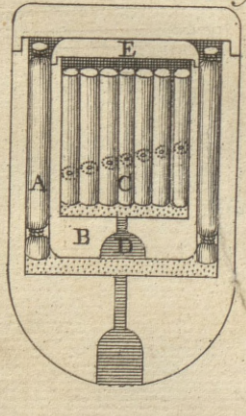


Fig. 99.



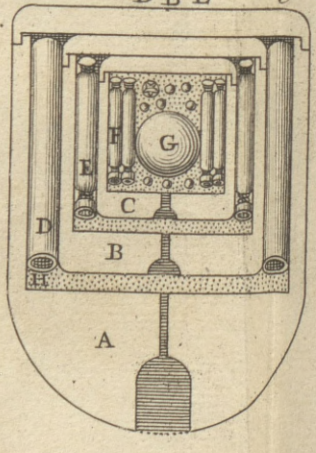


Fig. 100.

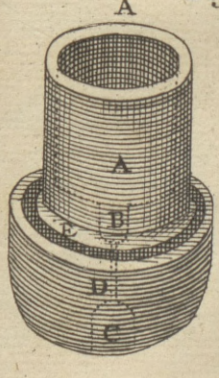
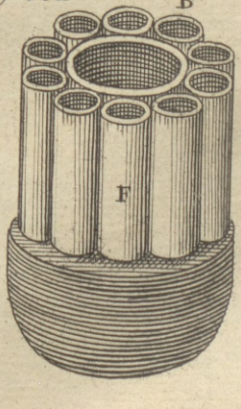


Fig. 101.



K

P.F. sc.

Find out the Height of the *Powder* between e and c, which we will here ſuppoſe to be 20 Parts or Diviſions of your Scale; and the Height between c and a, or that of the whole Chamber, which we will ſuppoſe to be 45 of the aforementioned Parts; the mean Proportional between theſe two Numbers (*viz.* 20 and 45) being about 30; ſay, As 30, the Proportional Number immediately found, is to e c, the Height of the *Powder* in the Chamber which is 20 Parts of your Scale; ſo is c d or a b, the Breadth of the Chamber of the *Mortar*, which is 24 of the ſame Parts, to the Diameter or Breadth of the Chamber you would prepare. This performed, you will have 16, which will be the Diameter of the Orifice ſought. Hollow out then of your ſolid Wooden Cylinder l o, equal in Height to the Chamber of the *Mortar* a d, the Concave Cylinder g k, the Diameter of whoſe Orifice g h is 16 of the ſame Parts with the 45 which conſtitute the Height of it l n, or g i: Thus will you have a Chamber of a Size requiſite for your Purpoſe.

Obſerve here, that in this Caſe, and in ſuch a Chamber, it is not at all neceſſary to preſs down the *Powder*, and that it will be better to have the Interſtices of it free and open, that the Air may be diffuſed throughout it, and that the *Fire* may have free Paſſage to inflame it all at once, and inſtantaneouſly.

If this kind of Chamber does not pleaſe you, get a Wooden Former whoſe Diameter is equal to the Cavity of the laſt mentioned Chamber, and either paſte or rowl as much ſtrong Paper upon it, as may give it ſuch a Thickneſs and Length as exactly to fit the Chamber of the *Mortar*. You have the *Figure* of this in D. It is my Opinion, that there can be no better Reaſon given, why *Powder* when confined in a long narrow Chamber, ſhould have a more violent Effect, than when an equal Quantity of it is lodged in a broad ſhallow one; than that the *Powder* is much more united in the Former than in the Latter, where it is more extended; from whence it happens, that the Denſity of the *Fire* iſſuing from the cloſe confined *Powder* is more conſiderable, the Exhalations and Expanſion much more abundant; the Union of the Parts of the *Fire* much more perfect; and conſequently the Flaſh muſt be every way more powerful, as I ſaid above.

In a Word; I believe the true Reaſon why the *Ancients* invented *Chambers* for their *Mortars* and *Cannon*, was becauſe thoſe Engines were chiefly deſigned for projecting *Stone-Bullets*: But as in thoſe Times they alſo uſed *Mortars* for throwing out certain *Pyrotechnical Globes* (as is ſtill practiſed, and to which we have lately added *Bombs*, &c.) which requiring but a little *Powder* in Proportion, to what was neceſſary to project thoſe ponderous Bodies of Stone; if their ſmall Requiſite had been lodged in a ſpacious Cavity it could have performed no notable Effect, for want of being collected in a cloſe Body: To remedy this Inconveniency, the antient *Pyroboliſts* contrived Chambers in their *Mortars* which are as it were little Magazines for keeping the *Powder* cloſe toge-

ther, that by the Proximity of its Corns, its expulſive Force might be perfectly united, and acting impetuouſly upon the Projectile, oblige it to depart as faſt as its Weight will permit. I have however often obſerved, that the Chambers in old *Mortars* and *Guns* were much larger than ours, the Reaſon of which was, becauſe their *Powder* was much weaker than ours, which was owing to the ſmall Quantity of *Saltpeter* in it; wherefore it was neceſſary that their Chambers ſhould be proportionably large. This, the Modern *Pyroboliſts* have altered; for in our Days, that *Mars* ſeems to have been more inſolent and outragious than ever, thoſe who have had the ordering of the *Artillery* have greatly leſſened the Chambers, becauſe our *Powder* is much more ſtrong, than what was formerly uſed; and therefore our Chambers muſt be proportionable to the Virtues and Qualities of the *Powder* they are to contain. If what I have been here ſaying, does not ſeem ſufficient to you, to clear up what I have here offered concerning the weaker or ſtronger Effects of *Gunpowder*, in proportion to the Capacity of the Chambers where ſuch Effects are produced, I ſhall ſtill farther endeavour to illuſtrate it by an Example of *Pneumatical Engines* or *Wind-Guns*; for if into any two of them of equal Capacity you inject an equal Quantity of Air, it is certain that the Air ſo condenſed being ſet at liberty, would ruſh with much more Noiſe and Impetuouſneſs through a narrow Tube, than through a broad one, and attack any Obſtacle in its Way, and impel it with a Power, much more conſiderable than the other, and all from the different Size of the Tubes or Barrels; (if we are here to underſtand *Wind-Guns:)* and it is certain that in unequal Capacities the greateſt or leaſt Quantity of Air would help or hinder the Violence of the Air iſſuing from two unequal *Engines* or *Guns*; for that Quantity of Air which was ſufficient to ſwell or fill up a ſmall Tube, would not be enough to fill up a larger Tube; but would diſperſe on all Sides, and diffuſe itſelf throughout the whole Capacity of it, and could not be ſo much condenſed in its Excurſion through a Space where it has room to expand itſelf. Thus is it with *Hydraulic Machines*, which throw up their Water the higher, the narrower their Pipes are; which alſo moves with a greater Horizontal Velocity, than that which runs through large Pipes or Channels; ſuppoſing ſuch Water to run in Channels or Pipes equally inclined to the Plane of the Horizon, and to be of equal Quantity, *&c.* The Cauſe of theſe different Effects may be accounted for, by what we ſaid above, (namely) That it is more compacted in narrow Channels, in which being hurried along by any Force impreſſed, or only left to the liberty of running its inclined Courſe, it flows along with wonderful Rapidity. It is quite different in ſpacious Channels, where the Water has room to ſpread abroad. Apply this now to *Gunpowder* in the Chambers of Warlike Engines, where being converted into a Fiery Spirit, which when it finds itſelf oppreſſed and pent up in a narrow compaſs, exerts its whole Strength to diſengage itſelf from all

manner

manner of Reſtraint, and having forced a Paſſage to the Air, it violently explodes and diſperſes that Element, which inſtantly cloſing together again, produces that ſhocking Clap which is heard upon the diſcharge of all Pieces of Ordnance.

COROLLARY IV.

Of Recreative Petards *or* Crackers.

WE have often mentioned *Petards* or *Crackers* in the preceding Chapters; but have ſaid nothing yet of their Conſtruction. You muſt know then, that there are two Sorts of *Petards*, which the *Germans* call *die Schlage:* One Sort of them being uſed in *Recreative Fire-works*; (which only I ſhall here treat of) and the other is applyed to Serious and Warlike Uſes, concerning which we ſhall ſpeak hereafter. The Form then of the Recreative Sort may be very much varied. Now of an infinite Number of them, thoſe which you ſee in *Figures* 105, 106, 107 and 108 in A and B, are ſuch as I chooſe to give you the Repreſentation of. Some of theſe are made of Paper; as you may ſee by B, in *Fig.* 105 and 108; which are formed in Moulds particularly contrived for them, one of which we have already repreſented and deſcribed in Book III. Chap. III.

Others are made of Iron and Copper Plates, and ſome of Lead as may be ſeen in *Fig.* 106, 107 and 108, diſtinguiſhed by the Letter A.

Thoſe which are made of Paper after the manner that you ſee in *Fig.* 105 and 106, have their Upper Parts (diſtinguiſhed by A) filled with *Corn Powder*; and their Priming-Chambers muſt reſt upon one and the ſame Plane, that they may not all go off at once, but by Intervals one after another. The Chamber of the Firſt towards the Right Hand, ſhall be Subquadruple of the Laſt towards the Left, as well in thoſe of Paper as thoſe made of any thing elſe. As for the Proportion of the Chambers between the Firſt and the Laſt, they gradually increaſe in going upwards, and conſequently the *Compoſition* in them muſt increaſe in Proportion: This may be readily conceived by the Oblique Lines b and c, upon the one and the other *Scenographical Figure*, which are Parallel to two other Oblique Lines diſtinguiſhed by d, and which terminate all their Heights in ſuch manner, that they are all of an equal Capacity, with regard to that Part of them which is filled with *Corn Powder*. The Inequality of their Chambers ſhall be then contrived as we juſt now ordered, and ſhall be filled with a *ſlow Compoſition*, which we have already given you, or elſe with the following *Compoſition*. Fig. 105. and 106.

Take of *Meal Powder* 3 Parts, and of *Coal* one Part, beat them and incorporate them well together. Carry this *Compoſition* into ſome damp Place,

Place, that it may contract a little Moiſture, and by that means be the more eaſily conſolidated; or elſe you may ſprinkle it over with a little *Oil* of *Petrol* or *Linſeed.*

In the *Iron Crackers* you muſt have little Iron Partitions to ſeparate the *Compoſition* from the *Corn Powder:* Theſe Partitions muſt be pierced in the Middle, that the *Fire* may have Conveyance to the *Corn Powder.* In *Paper Crackers* what we call the Priming-Chambers and Orifices, muſt be made juſt after the ſame Manner as we choak *Rockets,* with this Difference only, that they muſt be choaked cloſer in theſe than in thoſe, according to the Size and Quality of your *Crackers.*

Fig. 107. As for thoſe which you ſee in *Fig.* 107, they are filled only with *Corn Powder,* and ſtopped well up at Top with Paper or Tow, and have ſmall Vent-holes at Bottom where they receive the *Fire.*

Fig. 108. In ſhort, thoſe *Crackers* which you ſee in A *Fig.* 108 are cloſed up both at Top and Bottom with thin Iron Plates, which muſt be well ſoldered to the Tube, and pierced. As to the Method of charging them, you make an Hole in one Side of them to put in *Corn Powder.*

That which you ſee in B, muſt be ordered after the following Manner: After having choaked it cloſe up at Bottom with ſtrong Packthread or Cord, fill it up with *Powder,* and choak it cloſe at Top. This done, bore an Hole through the Side of it, into which you ſhall put a little Iron or Copper Fuze filled with *Meal Powder.* Thus you will have your *Crackers* ready for Uſe, and properly adjuſted.

Sometimes inſtead of *Crackers* we uſe hollow Leaden Bullets (which are mere *Grenado's)* which are filled with *Corn Powder*; we have applyed ſeveral of this Sort to our *Water-Globes* in this Book, Chap. I. Beſides theſe there are others made in Form of a *Cube,* ſome of a *Tetrahedron,* others of a *Priſm,* and in many other Shapes *Regular* and *Irregular.*

PART II. *of this* BOOK.

Which TREATS of

FIRE-GLOBES; or *BALLS*

PREPARED FOR

MILITARY USES.

THE Number of *Artificial Balls* prepared for the ſeveral *Military Purpoſes* is almoſt infinite, ſo that it is impoſſible to give an Account of them all: For which Reaſon I ſhall only touch upon ſome of the beſt and principal of them; but more particularly upon thoſe which are uſed in our Days; which I ſhall in this *ſecond Part* of this *Book*, delineate and explain to our *Pyroboliſt* with all the Perſpicuity and Accuracy I am able. I ſhall allot a Chapter to each Sort of them, in Conſideration that they differ pretty much from each other in Effect; and are diſtinguiſhed accordingly by particular Appellations.

CHAP. I.

Of Hand-Grenado's.

SORT I.

AS to the Form of *Hand-Grenado's*, it is perfectly Spherical, as is alſo the Cavity in the Middle of them; and they are called *Hand-Grenado's* from being graſped, and thrown by Hand, to annoy the Enemy. If we would ſtick to the *Latin* Denomination of them, we ſhould call them *Palmary Grenado's*, becauſe their Hemiſpheres commonly fill

up the Palm of the Hand; for they are usually of the Size of an Iron Bullet of 4, 5, 6 or 8 ℔. They sometimes weigh 1 ℔ or 1 ½ ℔, and sometimes 2 or 3 ℔. They are called *Grenado's* from the Resemblance they bear to the † *Punic Fruit* which we call *Pomegranates*; for as the Rind of these incloses a vast Number of Grains, from whence they derive their Name of *Granates*; so our *Military Grenado's* are filled with innumerable Grains or Corns of *Gun-powder*, which taking Fire, burst them into a thousand Splinters, which fly against, and grievously oppress the Enemy; therefore *Leonard Frontzberger* in his *Artillery* calls them *springende* and *schlagende Kugelen*; which is as much as to say, *leaping* or *bounding*, or rather *striking Balls*, if we may so express ourselves. Now this last Appellation of these *Balls* may be very properly applyed to all the greater *Grenado's*; which doubtless borrowed their Name from the smaller Sort, which have a greater Natural Resemblance to the *Punic* Fruit above-mentioned than the Larger have: Add to which, that it is certain the Small ones were used before Men (industrious to each other's Ruin) invented the Great ones. And indeed we do not find the least Footsteps of the great *Grenado*'s amongst the ancient *Pyroboliſts*; but their Writings make ample and particular mention of the smaller as what they were perfectly well acquainted with, tho' at the same time it must be confessed that they called them by other Names, and treated of them in a different Manner from us. *Boxhornius* relates something which agrees pretty well with our Sentiments concerning *Hand-Grenado's* in his History of the *Siege of Breda* in the Year 1617.

Grenado's (says he) *which we have so often mentioned, derive their Appellation from their Resemblance to* Pomegranates; *and are hollow Iron or Brass Globes, the Diameter of whose Cavity is* 3 Unciæ *or Inches, and whose Thickness of Metal is* 3 *Lines. They are filled with* Gun-powder, *and sometimes with particular* Compositions; *in their Vents they have Fuzes which are slow indeed in Combustion, but very susceptible of Fire, and calculated to burn for some time, to avoid the danger of their bursting in the Hands of those who throw them.* The same Author says in another Place, *That they forbore to throw those Balls which derive their Name from the* Punic *Apple*; *because as they required a good deal of* Powder, *and the Besieged falling short in that Article, they could not afford to supply them with it.*

But it were to no purpose to dwell any longer on the Etymology of these *Balls*, since every Body knows what is meant by them. Let us then proceed to the Order observed in the Preparation of them; which indeed is somewhat needless after what we have quoted from *Boxhornius*: But however I must beg Leave to add three or four Words which shall savour more of *Pyrotechnics* than of History.

† This is the same with *African* and *Carthaginian*.

With

With regard then to the Matter of which they are formed, *Hand-Grenado's* may be ſaid to be of three Sorts; the Firſt and moſt common of which are made of Iron; the Second of Braſs mixed and allayed with other Metals; and the Third of Glaſs. If you would have them of Iron, they muſt be the moſt brittle and the leaſt wrought that they can poſſibly be. If you would have them of Braſs or Copper, you muſt mix 6 ℔ of Copper with 2 ℔ of Tin and half a ℔ of Marcaſite; or elſe it ſhall be one ℔ of Tin, with 3 ℔ of Lattin. Thoſe which are made of Iron, ſhall have their Metal throughout, of the Thickneſs of $\frac{1}{5}$ of their Diameters. Thoſe which are made of Braſs ſhall be $\frac{1}{10}$. And thoſe which are made of Glaſs, ſhall be $\frac{1}{7}$ of their Diameters in Thickneſs, as may be ſeen in the *Fig.* 109 under the Letters A, B and C. Fig. 109.

The Diameter of the Vent ſhall be $\frac{2}{3}$ of the Diameter of the *Grenado*; and the little Hole ſhall be $\frac{1}{12}$ of the ſame Diameter: It is through this that the Body of the *Grenado* is filled with *Corn Powder*.

The Fuze which you ſee in the Letter D, ſhall have its Diameter from Outſide to Outſide $\frac{2}{3}$ of the Diameter of the *Grenado*, or it ſhall be a little leſs that it may eaſily ſlip down into the Vent. The Length of this Fuze ſhall be $\frac{2}{3}$ of the ſame Diameter; and the Hollow of it ſhall be $\frac{1}{2}$, and the Top of it ſhall be a concave Hemiſphere, as may be ſeen by the aboveſaid *Figure*. This Concavity muſt be filled with *Powder* finely mealed, which muſt be moiſtened with a little Gum or Glue Water, that it may ſtick together the cloſer. As for the Body of the Fuze itſelf, it ſhall be filled with one of the *Compoſitions* here-under given; then capped with Tow, and ſome of that *Pyrotechnic Cement* which the *Germans* call *Kit*; which is made of 4 Parts of *Ship Pitch*, 2 Parts of *Colophone*, one Part of *Turpentine*, and one Part of *Wax*; theſe are all put into a glazed Earthen Pot, melted over a ſlow Fire, and mixed and incorporated well together.

Compoſitions *for the* Fuzes *of* Grenado's.

I.

Of *Powder* one ℔; of *Saltpeter* one ℔; of *Sulphur* one ℔.

II.

Of *Powder* 3 ℔; of *Saltpeter* 2 ℔; of *Sulphur* one ℔.

III.

Of *Powder* 4 ℔; of *Saltpeter* 3 ℔; of *Sulphur* 2 ℔.

IV.

Of *Powder* 4 ℔; of *Saltpeter* 3 ℔; of *Sulphur* one ℔.

SORT

SORT II.

The *Hand-Grenado* I am now going to deſcribe, differs in no reſpect from the former, excepting in its Fuze, which is otherwiſe contrived, and which together with ſome other minute Circumſtances, is all that conſtitutes this, a *Grenado* of a different Sort from the foregoing. We
Fig. 110. have given you a Repreſentation of this in *Fig.* 110; in the Preparation of which you are to take Notice of the following Rules. Firſt, get a Wooden Fuze made (though it may be of ſome Metal if you will) whoſe Length is equal to the Diameter of the *Grenado*, and its Breadth equal to the Diameter of the Vent; but it ſhall be thicker and larger at Top by $\frac{1}{5}$ of a Diameter, where it is to be hollowed out in a Concave Hemiſphere. The lower Part of it, which is to go down into the *Grenado*, ſhall be bored with ſeveral Holes which ſhall be filled with *Meal Powder*. This done; fix it in the *Grenado* in ſuch manner that the lower End of it may reſt upon the Bottom of the Shell, and ſecure it as we ſaid before; then fill the *Grenado* with good *Corn Powder*, which you are to do by a little Hole on one Side of it, which ſhall afterwards be ſtopped up with a little Wooden Pin or Spile which muſt be very forcibly driven in. The Head of the Fuze ſhall be crowned or adorned with Sprigs of freſh and green *Box*, which ſhall be tied with Packthread, to keep them faſt whilſt they are handled.

When you would put theſe *Grenado's* in Practice, take a little End of Match, of ſuch Size as to be able to ſlip readily down the Hollow of the Fuze, and tye a little Leaden Bullet to the lower Extremity of it. Then light your Match, and as ſoon as it has acquired a good Coal, put it into the Fuze with its Bullet downwards, and throw the *Grenado* where you think fit; and be aſſured, that as ſoon as it ſtrikes againſt the Ground, the Leaden Bullet and its Match will fall down in the Fuze, and by lighting the *Meal Powder* in the Side Holes of it, will fire the *Grenado* and ſplit it into a thouſand Pieces. The Sprigs of *Box* are not deſigned ſo much for Ornament as Uſe in this caſe; for they ſerve to keep the Vent of the *Grenado* upwards, or in a Vertical Poſition whilſt it is in the Air, ſo that falling upon its Bottom, it may ſhake down the Leaden Bullet, and conſequently the Match with it: This Contrivance may likewiſe be of Uſe to other Bodies which are to fall down upon Horizontal Planes.

This *Grenado* is moſt frequently armed with Leaden Bullets; that is, the Outſide of it is covered with them, that it may do the greater Execution. In order to do this, you muſt firſt coat the *Grenado* with melted Wax which muſt have a certain Quantity of *Colophone* mixed with it; into which you may ſink as many Muſquet Balls as you pleaſe whilſt it is cooling: Then wrap the Whole up in a Cloth, and bind it well round with Packthread.

SORT III.

In *Figure* 111, I give you the Repreſentation of a *Hand-Grenado* Fig. 111. (though it may be of a larger Size if you will) which may be privately hid at the Entrance of any Avenue, or in any narrow Paſſage, through which you expect the Enemy to come. This *Grenado* has two Holes Diametrically oppoſite to each other; through which paſſes a Wooden or Metal Fuze, pierced all round with Holes, primed and ſalted over with *Meal Powder*; through this Fuze you draw a piece of common Match lighted at one End: The *Vertex* of this *Grenado* has a Third Hole (or Vent) where you fill the Cavity of it with *Corn Powder*, which being afterwards firmly ſtopped up with a Tompion, your *Grenado* will be prepared. I believe I need not teach you the Uſe of this, which you may eaſily gather from the *Figure* itſelf, and which upon occaſion Neceſſity may ſuggeſt to you.

COROLLARY.

How to Throw or Deliver Hand-Grenado's.

AFTER our Definition and Deſcription of theſe *Grenado's*, we need not tell you that they are graſped and thrown by Hand, at ſuch times as the Enemy is within the reach of your Strength: Nor need we tell you that they are both Offenſive and Defenſive *Arms*, which thoſe who know nothing of the matter, may learn from ſuch as have been preſent at *Sieges*: We ſhall only add, that *Hand-Grenado's* are very much uſed after the happy Succeſs of a *Mine*, which has made a Breach in ſome Rampart, thrown down a Wall, or blown up a Baſtion; it is then that they are uſed to clear the Way in mounting the Breach: It is upon ſuch occaſions, that you ſee the moſt generous and brave of each Side, armed with Fire and Flame, valiantly maintaining the Cauſe of their Prince, the Intereſt of their Country, their Liberties and their Lives. Or when the Beſiegers have got to the Foot of a Rampart, and are obſtinately bent upon inſulting it, and inſenſibly ſcale it; (being covered by the Rampart itſelf from the Defences of the Flanks:) It is then that the Beſieged are to ſhower down *Grenado's* upon the Enemy, and of which the Beſiegers are to make the beſt returns they can, to procure themſelves a free and ſafe Paſſage; as was not long ſince ſeen at the *Siege* of *Hulſt*, which was taken by the *Hollanders*. But it is impoſſible to enumerate the ſeveral particular Uſes of *Hand-Grenado's* in the Occurrences of War, and eſpecially when both Armies are ſo near as to be almoſt at Handy-cuffs with each other. It it ſometimes neceſſary to

throw them at great diſtances; but here I mean one after another: I ſhall hereafter ſhew how to throw ſeveral together, which being a Work unequal to the bare Strength of a Soldier, the Maſters of this *Art* have invented little convenient *Machines* for that Purpoſe; the beſt Sort of
Fig. 112. which I repreſent in *Fig.* 112, after having made ſome neceſſary Additions to it. With this *Machine* you may not only throw *Hand-Grenado's*, but ſeveral other Sorts of *Military Fire-Works*, ſuch as *Light Balls*, *Bombs*, *Fire-pots*, *Fire-hoops*, *Garlands*, and *Crowns*, and ſeveral other ſuch like things, which we ſhall ſpeak of in their proper Places.

There is nothing difficult in the Conſtruction of this *Machine*, and it may be eaſily comprehended by the *Figure* itſelf: I ſhall only add, that ſo much the longer that Arm of it is, which is made in the Form of a Ladle (into which the *Grenado* is to be put) than the other Arm to which the String is faſtened, ſo much the more powerful will it be. You muſt here underſtand their Length to be meaſured from the Center of the Iron Spindle, upon which they turn, to one and the other Extremity of the Arms; and in this they imitate a Balance.

Boxhornius alſo mentions, in the above-quoted Place, a certain new invented *Machine*, made like one of our *Mortars*, and well fortified with Iron Rings, with which they ſhot *Hand-Grenado*'s into *Breda* during the *Siege*. And it is not long ſince we ſaw at the *Siege* of *Hulſt*, and ſince then at *Murpſey*, which is a pretty ſtrong Place, a like *Machine* conſtructed by a bold *Engliſh* Soldier, who preſented it to *Frederic Henry* Prince of *Orange*, of immortal Memory; of whom this *Engliſhman* demanded 100 *Dutch Florins* for the Trouble he ſhould take, and the Danger he ſhould incur in throwing his *Grenado's*: In ſhort, he obtained his Demand, and began to play his *Machine*; but to ſay the Truth, he did it ſo aukwardly, and with ſo little Judgment, that the greateſt part of his *Grenado's* either did not reach the Place they were deſigned for, or broke in the Air; which was attributed to the Defect and Imperfection of the *Engine*, together with the Ignorance of the Engineer who wanted Skill to govern it.

We ſhall, in the Second Part of our Work, give you a Treatiſe upon *Mortars*, in which we ſhall take occaſion to ſpeak of a little *Machine* of our Contrivance, more perfect and artificial than this, for projecting *Hand-Grenado's*, or greater Shells if you will, and to throw them juſt where you pleaſe: But that for which it is as uſeful as admirable, is its being able to throw ſeveral at once, as for inſtance 7 at a time, or one after another according as the Exigence of Affairs requires; to which I for the preſent refer the Reader who is ſo curious as to want the Conſtruction of it.

But upon the whole I cannot help admiring at the rigorous Sentence, which the firſt Inventors of our *Art* paſſed upon the *Warlike Machines* of the Ancients, as if guilty of ſome notorious Crime, for which they reſolved entirely to baniſh them from the *Modern Arts of War*;

and

and to carry their Contempt of them ſo far, as to burn them ignominiouſly in their Kitchens, that there might not remain any Footſteps of them; conceiving perhaps that their Succeſſors, convinced of their Innocence, might one time or other recal them from Baniſhment, if they were not utterly deſtroyed. And indeed if the Writings of ſo many great Men their Contemporaries, who had ſeen their wonderful Effects, did not bear witneſs of the great Services they did, whilſt they were in their greateſt Splendor and moſt venerable Majeſty, we ſhould never have known any thing relating to their Conſtruction. An ungrateful Return ſure they meet with, for their great and mighty Performances! Muſt Contempt be the Reward of their illuſtrious Executions, by means of which *Rome* became Miſtreſs of the *World*, and triumphed over Nations and Kings till then Invincible? No: it would be in vain to dwell upon this Subject; they have ſuffered great Injuſtice, and ſtill continue to ſuffer it, and are now not even admitted into the moſt inferior Claſs of the Servants of *Mars* and *Bellona*, but are totally rejected, and condemned to an inglorious Inactivity; and are ſo far ſunk in Point of Reputation, that whoſoever offers any thing in Favour of them, is ſneered at by a Pack of ignorant Fellows, who openly ſcoff at the great Exploits they formerly did, and look upon them as Romances and old Women's Tales.

But to what purpoſe do I waſte my Time in defending the Cauſe of thoſe injured Inventions? *Lipſius*, the greateſt and beſt Judge that ever was of the Ancient and Modern *Arts* of *War*, has ſufficiently pleaded in their Behalf; to whom we are infinitely obliged for the Trouble he has been at in tracing out the Uſes and Services of them: It is from him that we have collected ſo rich a Store of what concerns the wonderful *Machines* of the Ancients, and which we ſhall dwell upon when we come to compare them with ours. My ſole Deſign at preſent is to evince, that all the Sorts of *Grenado's*, and the other *Pyrobolical* Inventions in preſent Uſe (which might be projected by the *Slings*, and † *Fundibali* of the Ancients but not by the *Baliſtæ*) may be ſlung very conveniently to very great Diſtances.

Firſt then; I beg of you to liſten to what I am going to ſay of the ſurprizing Strength and admirable Effects of *Slings*, which indeed are ſo very great, that when I firſt read and conſidered them, I was perfectly tranſported. *Ovid* ſpeaks ſomewhere of them to this Purpoſe.

Non ſecus exarſit, quam cum Balearica Plumbum
Funda jacit, volat illud & incandeſcit eundo
Et quos non habuit, ſub nubibus invenit Ignes.

In *Engliſh* thus:

It burns, as when from *Balearic* Thong,
The pond'rous Lead with nervous Force is ſlung;

† Theſe were a kind of *Slings*.

Which

Which flies and whiſtles through the airy Height;
And glows with raging Heat contracted in its Flight.

By this it appears, that in his Time they uſed the *Sling* for *Leaden Balls*, which were perhaps filled with Combuſtible Matter, ſince he ſays that they took Fire in their Flight, and acquired a Flame in the Air by their violent Motion. *Lucan* ſays as much:

Inde faces, & ſaxa volant, ſpatioque ſolutæ
Aëris, & calido liquefactæ pondere glandes.

In *Engliſh* thus:

There Fiery Darts, and rocky Fragments fly;
And melting Bullets whiſtle thro' the Sky.

All theſe *Fire-Brands* or *Darts*, *Flying Stones*, *Melted Bullets*, which he here ſpeaks of, were the true *Fire-Works* of his Time, which they ſhot at the Enemy with *Slings*, or ſome ſuch Contrivance.

I ſhall paſs over ſeveral other Authors, the Teſtimony of whom is collected by * *Lipſius* to prove what he ſays of *Slings*. But I cannot omit what † *Seneca* ſays in his *Natural Queſtions*. *Motion* (ſays he) *rarifies the Air, and that extreme Rarefaction generates Heat: Thus a Bullet projected from a* Sling *is melted by the Attrition of the Air as much as it would have been by* Fire. Does not this appear very ſtrange? Surely if we had not the Teſtimony of ſo many great Men, we ſhould at once look upon theſe as Romantic Fables. *Joſeph Quercetan* ſeems to think them Fabulous in his Book of the *Carbine*, where he diſputes againſt || *Ariſtotle*; who ſays, *That the Darts and Javelins were ſo heated by the Friction or Attrition of the Air, that they were hot enough to melt Lead.* This, *Quercetan* flatly denies; inaſmuch as Experience teaches the contrary, by ſhewing that *Muſquet Balls*, &c. which are projected by *Fire*, and that with greater Violence (theſe are his Words) than any Arrow or Dart can be ſhot, are not heated to that degree. Let us now examine into the Weights, Sizes, and Qualities of theſe Bodies; and at the ſame time we ſhall ſee how far the ancient *Slings* could throw them; which is partly the End and Aim of this Eſſay.

Diodorus Siculus ſpeaking of the Inhabitants of the |||| *Balearic Iſlands*, ſays, ‡‡ *That they were the moſt dextrous People in the World at ſlinging great Stones.* The ſame Author ſays elſewhere of theſe Iſlanders, *That they had acquired ſuch a Perfection in the Exerciſe of the* Sling, *that they could caſt great Stones with ſuch Strength and Violence that they ſeemed*

* Lipſius Lib. V. Dial. ſeu Coll. XX. de Mil. Rom.
† Sen. Cap. LVI.
|| Ariſt. de Cœlo, Cap. VII.
|||| Theſe are now called *Majorca* and *Minorca*.
‡‡ Diod. Sic. Lib. VI.

rather

rather to be ſhot from † Catapultæ, *ſo great and violent was the Blow they gave! which broke Shield, Helmet, and every other kind of Armour, though never ſo well tempered.* An uncertain Author in *Suidas*, ſays of the ſame People, *That they ſlung Stones of the Weight of a Mina:* By which he means an *Attic Mina*, which weighed 100 *Drams*, as we have ſaid elſewhere; but *Cæſar* calls them *Libral* or *Pound Slings.* So much for the Weight of the Stones they uſed to ſling; which, according to what we have ſaid above, agrees pretty well with the Weight of our *Hand-Grenado's.* We are told alſo that beſides Stones, They uſed to ſling *Leaden Balls* at their Enemies, without the Aſſiſtance of any Engines but their *Fundæ* or Slings; which we cannot compare with any thing more properly than with our *Grenado's.* An uncertain Author in *Suidas* ſays, *That the* ‡ Cadurci *were reckoned the beſt Slingers; and that they could caſt Stones and Leaden Balls to that Nicety as never to miſs their Aim.* They had farthermore a way of ſlinging Pots full of *Fire*, into the Places they Beſieged when they were near enough to do it, or had got Poſſeſſion of the Outworks: But I cannot avoid thinking that theſe *Fire Pots* were heavier than our *Grenado's. Appianus* in his *Libic.* ſays, *That the* Romans *had raiſed high Terraſſes oppoſite to thoſe Towers; from whence they threw a great Number of lighted* Torches *and* Fire-Brands, *together with Veſſels full of* Sulphur *and* Pitch. And *Dion.* in *Lib.* XX. ſpeaking of the Time when the *Romans* beſieged the *Capitol*, which their Slaves had poſſeſſed themſelves of, ſays, *That there were Thoſe who ſlung* Veſſels *full of* Bitumen *and boiling* Pitch *from the Houſes in the Neighbourhood of the* Capitol. However this was, we muſt believe it ſince they ſay it: But all theſe things were only ſo many Forethoughts of our *Hand-Grenado's.* You will find ſtill ſomething farther to this Purpoſe in || *Julius Cæſar's Commentaries*, where he ſays, *That a great Wind riſing, the* Gauls *began to ſling upon our Cabbins and Huts (which were only thatched with Straw after the Faſhion of the Country) hot* Balls *which were made of a fuſible Earth; and at the ſame time ſhowered a vaſt number of very hot* Javelins *upon us.* But *Lipſius* is of Opinion, that this ought to be rendered *Earthen Veſſels filled with melted or boiling Matter. Oroſius* ſpeaking alſo on the ſame Subject, ſays, *That they took red-hot Pots or Earthen Heads, and threw them at their Enemies.*

It was thus that the *Romans* and the moſt Warlike Nations their Contemporaries uſed the *Sling*, as well in attacking their Enemies as defending themſelves. If you would know in what great Eſteem they were held within the Memory of our Fathers amongſt our *Northern* Neighbours, even ſince the Invention of *Gun-powder*; conſult *Olaus* the great Archbiſhop of *Upſal*, who was one of the moſt learned Writers

† Theſe were Warlike *Engines* to ſhoot Darts or Stones.
‡ The ancient Inhabitants of *Guienne* in *France* were formerly ſo called.
|| Jul. Cæſ. Com. VII.

that ever lived in the North; and who ſpeaks in theſe Terms: † *The* Aquilonians, *or* Northern *People, when they deſign to beſiege ſome Town, or attack a Camp, have certain flexible Chains, or a kind of Links and Joints of Iron made faſt to Sticks or Staves, which they prefer to all other Arms, particularly when the Country is ſtony. But in ſuch Places where they can get no Stones nor Pebbles (which ſeldom happens in thoſe Parts) they ſling pieces of red-hot Iron, which they put into the Purſes of their Slings with Pincers. You always ſee them with a certain Veſſel in their Hands made like a* Roman Barrel, *full of Cruſts and Pieces of Iron, which being heated red-hot, and ſlung at the Enemy, they make ſo ſtrange and dangerous a Wound, that whoever has the Misfortune of being ſtruck by them, muſt hope for no Help from any Phyſician or Surgeon. And the reaſon why this Iron wounds ſo dangerouſly and irrecoverably* (obſerve this) *is becauſe of its Weight and the Aduſtion it cauſes in the Part. The Remembrance of an Event like this, is ſtill freſh in the Perſon of* Chriſtiern *the* IId *King of* Denmark, *who loſt a mighty Army in the Year* 1521, *at the City and Camp of* Aroſen, *by means of ſuch contrived Arms. For here they did the ſame with burning* Darts, *which being taken with Iron Pincers from the Fire, and put upon* Balliſtæ (for they promiſcuouſly uſed the ancient and modern Machines together) *they were ſhot from them, and wounded the more incurably, according to their degree of Heat, which made it ſometimes impoſſible to draw them out with the Hand: But what was the moſt diſaſtrous and dreadful; theſe burning Darts and Pieces of red-hot Iron, falling upon their* Gun-powder *it was inſtantly fired, and went off with a deafning Clap, and burned and ſtifled all the circumadjacent Soldiers; and what ſtill added to their Misfortune, was the Incurſions and Outrage of the Mountaineers, (a Savage Brutal Race bred in Subterraneous Caverns and Mines) who overwhelmed them with Darts, Stones, and Pieces of hot Iron, which they ſhowered upon them with their* Slings. *I ſaw* (ſays he) 250 Italian *Miles from thence, ſeveral that were brought by Sea to* Stockholm; *a moſt terrible Sight to behold! ſome were without Noſes, others had loſt their Eyes, theſe their Arms, and thoſe their Legs: In ſhort, their Wounds being incurable, the* Germans, Scots *and* Danes *in particular, died in the utmoſt Miſery.*

Let us now have done with the Size, Weight, and Quality of the Bodies that were uſually thrown from the *Slings* of the *Ancients:* And indeed I believe I have ſaid enough on this Subject for you to draw ſome Conjecture of the Diſtance they could carry, as well as of their Certitude of hitting what they aimed at. But ‡ *Vegetius* ſpeaks very plainly of this Matter, when he ſays, *That the Archers and Slingers ſet up a ſmall Fagot, or Bundle of Straw for a Mark, from which they retired to the diſtance of* 600 *Foot, and hardly ever miſſed it with the Arrows they ſhot, or the Stones they ſlung.* We read alſo in Holy Writ, || *That among the In-*

† Olaus Lib. VII. Cap. VII. ‡ Veget. Lib. II. Cap. XXIII. || Judges Chap. XX. ver. 16.

habitants

habitants of Gibeah *there were ſeven hundred choſen Men left-handed, every one of whom could ſling Stones at an hair's-breadth and not miſs.* The *Roman* Surveyors had moreover a certain Meaſure which they aſſigned to Fields and Grounds, which anſwered to the Caſt of a Sling; from whence they called a Farm with all the Tillage belonging to it, *Fundus*, (which the *French* at this Day call *Fonds*;) whoſe Breadth and Length was a Sling Caſt. Thoſe who know any thing of this Meaſure, affirm that it was 600 Foot. We find ſomething to this Purpoſe in *Quintilian in Jocul.* in theſe Words.

Fundum Varro vocat, quem poſſim mittere Fundâ
Ni tamen exciderit qua cava funda patet.

But to what Purpoſe ſhould we dwell any longer upon the Power and Properties of the *Sling?* Let us now try whether or no, we can, according to the Rules of Modern *Architecture*, conveniently ſling *Grenado's* from our Lines of Approach into the Enemy's Intrenchments. Firſt then it is a general Rule amongſt our *Military Architects* or *Engineers*, to begin their Lines of Approach at the diſtance of 60 Rods from the Place Beſieged; if the Situation of it will not permit to break Ground nearer without Danger. This Diſtance is equal to the Level Range of Bodies projected from *Slings*; for it is thus that you muſt underſtand what *Vegetius* ſays above of the Exerciſe of the *Roman* Soldiers; which alſo is taken Notice of by ſeveral other Writers: And it is likewiſe with us the Practice of our Muſqueteers, to exerciſe themſelves at a Mark ſet up at about the Height of a Man, from whence they retire 200 or 300 Paces, to acquire a Certainty in their Aim, and to familiarize the thing to them, when they come to engage with the Enemy Face to Face. But as this Method of aiming is quite different from the Projection of our *Hand-Grenado's*, the former being Parallel to the Horizon, and the latter in a Curve, in which the Body falls into the Enemy's Works, we muſt find ſome other way of doing it.

Now it is very evident from the Obſervations on the Shots of our great Guns, *&c.* that the Line of Shot which the French call, *de niveau*, and the Italians, *de ponto in bianco*, and We, *point blank*, is the Tenth Part or thereabouts of the utmoſt Random, at an Elevation of 45 Deg.

It is farther certain, that all Projectiles obſerve one conſtant Proportion: Therefore if any one takes his Aim, to ſling an *Hand-Grenado* after having ſwung it a few times round his Head; and endeavours to throw it at the diſtance of 6000 Foot, or 600 Rods, which is ten times as far as the Spot where you begin your Lines of Approach is from the Place beſieged (provided always that it does not exceed 60 *Toiſes* or Rods, or 600 Foot) I do not in the leaſt doubt that it would fall within the Enemy's Walls; for all Thoſe who uſe the *Sling*, or throw any thing with

with the Arm only, are naturally led to project it in an Angle of 45 Deg. or thereabouts. But ſuppoſe they were to be thrown to the diſtance of 30 or 40 *Toiſes* only; who will deny that it may be very conveniently done by *Slings?* Provided they are always ordered and directed in the ſame manner as our Mortar-Pieces, when we would ſhoot *Bombs*, great *Grenado's*, and other *Pyrobolical Balls* from them to little Diſtances; that is, you muſt allow them the ſame Elevation; which is a Dexterity and Knack that might be eaſily acquired, partly by a previous Knowledge in *Gunnery*, and partly by continual Practice; for it was doubtleſs by Uſe and Cuſtom that thoſe Foreign Nations attained ſuch Skill in handling the *Sling*, as enabled them to do ſuch mighty Exploits, and to perform ſuch terrible Execution with it as they did.

I muſt confeſs, this is a Point which requires ſome Prolixity in the treating of it, but becauſe I do not think this a proper Place for ſuch a Diſcourſe I ſhall proceed farther on: And in the mean time only obſerve in what manner, the *Slings* being loaded with a *Hand-Grenado*, the Slingers may ſo contrive as to project them from the Trenches into the midſt of their Enemies. In order to this; lodge your Slingers upon the moſt advanced part of the *Lines*, in ſome Place where they may be in Safety, and under the Covert of a good *Parapet*; as for Example, in ſome *Redoubt* whoſe diſtance from the Top of the Gabions on the Enemy's *Parapet* ſhall be 500 Foot. Now that we may not ſeem to be too hard upon our Soldiers, whoſe Arms are not yet formed to this Exerciſe, and that they may not think we would impoſe Impoſſibilities on them, we will ſuppoſe that our *Hand-Grenado's* cannot be thrown to a greater Diſtance than 100 Foot; therefore (according to what we ſaid above) if they be projected at an Angle of 45 Deg. they muſt deſcribe a Curve of 1000 Foot: But as a Diſtance of 500 Foot requires that the Arm of the Slinger ſhould deliver the *Grenado* at an Angle of 10 Deg. (or $\frac{1}{9}$ of a Quadrant) beginning from the Center of the Arm that ſlings; therefore if the Slinger ſtands upon the Spot which terminates the Diſtance of the Place as aforeſaid, at 15 Foot from the *Parapet* of the Lines of Approach, and if from that ſame Point there be a Stake planted whoſe Height exceeds the meaſure of the Slinger from the Sole of his Foot to the Center of his Arm by 2 Foot 8 Inches, and whoſe Poſition is perpendicular and directly oppoſite to the place where you ſend your *Grenado's* (or elſe they will go wide of your Aim,) and if the Slinger remains fixed in that Point, and after having fired the Fuze of his *Grenado* in the Purſe of his Sling, he gives it one Turn only, and then throws it towards the beſieged Place, in ſuch a manner that the *Grenado* (every time he delivers one) almoſt touches the Top of the ſaid Stake, and if he has always the End of it for a Mark, he will never fail of ſending his *Grenado's* to the Place they are deſigned for; provided they are of equal Weight, and that their Fuzes are ſo ordered, as not to fire them before they are arrived at the intended Length. Now the

Fire

Fire of your Fuze will never go out if you fill it with one of the *Compoſitions* that we have given above, which I can venture to aſſure you of, having often uſed them with Succeſs for the Fuzes of great Shells that are ſhot from *Mortars*, whoſe Motion you may believe is none of the ſloweſt.

REMARK I.

By what we have ſaid of the *Stake* driven perpendicularly into the Earth, you are to underſtand that the Height of 2 Foot 8 Inches, over and above the Height of the Man from the Sole of the Foot to the Center of the Arm, is a Perpendicular in a rectangled Triangle, whoſe Baſe is 15 Foot: The Angle intercepted between the Baſe, which begins in the Center of the Arm of the *Slinger*, and the *Hypothenuſe*, which is the Hand that is lifted up with the *Sling*, is exactly 10 Deg. to which Angle, the Perpendicular beforementioned is directly parallel or oppoſite. The farther the *Slinger* removes from the Perch or *Stake*, the longer will the Perpendicular be; and on the contrary, the nearer he approaches to it the ſhorter. What I have here ſaid, is by way of Example only, inaſmuch as Baſes of various Lengths require different Perpendiculars.

REMARK II.

You muſt meaſure the Diſtance between the *Slinger* and the Tops of the Gabions on the Enemy's Ramparts in ſuch manner that there may be a Space of 15 Foot more or leſs between him and the *Parapet* of the Lines of Approach, which Baſe ſhall be terminated by the *Stake* abovementioned; leſt meaſuring the Diſtance from the Inner Height of your Parapet, you be obliged to expoſe yourſelf to evident Danger, by planting the ſaid *Stake* on the other ſide of your Gabions: But this may on the other hand be done within the Beſieged Place.

REMARK III.

The Strings or Reins of your *Slings* may be of Lengths ſutable to the Diſtances of Places, according to the Practice of the ancient Inhabitants of the *Balearic Iſlands*, who knew very well how to lengthen and ſhorten their *Slings* as occaſion required, if we may believe † *Florus*, who tells us, *Upon Warlike Occaſions they uſe three Sorts of* Slings, *ſo that it is no wonder they are ſuch good Mark's-Men, eſpecially when we conſider they have no other Arms, and are trained up to the* Sling *from the Cradle; and to harden them, it is the Cuſtom of the Mother never to give*

† Flor. Lib. III. Cap. VIII.

her Child any Victuals till ſhe ſhews it him with a good Blow. But let us hear what *Strabo* ſays of theſe Iſlanders; *They carry three* Slings *twiſted about their Heads, the Reins of one of which are very long for great Diſtances; of the other very ſhort, for ſmall Diſtances; and of the third of a middling Size between the two former, for middling Diſtances. Diodorus* would have them wear the Shorteſt round the Head, the Longeſt like a Girdle round the Middle, and carry the Middling one in their Hands.

REMARK IV.

Nothing can be more convenient or certain for throwing *Hand-Grenado's* than the *Sling*; for we have often obſerved, that when they are ſhot from *Machines* like *Mortars*, they are apt to break before they are projected, to the great Damage of the *Machine*, and Danger of the Perſons who play it. If on the other Side they are delivered from the Hand only, what Diſaſters are not thoſe liable to who are obliged to do it; beſides thoſe to which they are already expoſed? The ſeveral Sieges of our Time have all furniſhed us with diſmal Inſtances of the Ruin and Death of many a brave Fellow, to whom this Iron Fruit was more fatal, than hurtful to their Enemies: In good Truth, if my Maſter was here who taught me the firſt Rudiments of this *Noble Art*, he would be very ready to back what I have here offered, and (I dare ſay) would tell you, that if it had been the Cuſtom in his Time to throw *Grenado's* with a *Sling*, he had never loſt his Right Hand. Beſides the *Sling*, I approve very much of certain little *Machines* not very unlike the *Baliſtæ* of the Ancients; ſuch as we have already deſcribed; therefore I ſhall curſorily touch upon them.

We ſhall in the following Chapter treat of the great *Grenado's* that are uſually projected from *Mortars*; but I muſt by the way take Notice that they may be very conveniently ſhot from the *Baliſtæ* of the Ancients. I ſhall in Book I. Chap. I. of the *Second Part* of our *Artillery* dwell upon the Power and Effects of thoſe *Machines*, where I ſhall confirm what I ſay with the Teſtimony of ſeveral good Authors; and give you the Profils and *Scenographical Figures* of them, moſt curiouſly and exactly drawn, and occaſionally explain how the Ancients were wont to conſtruct them. Be ſatisfied at preſent with what ‡ *Joſephus* tells us of the incredible Power and Strength of the *Baliſta*, in his Account of the Deſtruction of *Jeruſalem*; where he ſaith, That *every Stone was of a Talent Weight; and did Execution not only at Hand, but to the Top of the Walls and Ramparts, though it were at a Furlong diſtance; and where it fell it carried a whole File before it.* And † *Diodorus*; Demetrius *placed in his* * Helepolis *ſeveral* Machines, *the greateſt of which carried Stones of three Talents. Athenæus* alſo ſpeaking of King *Hiero*'s Ship which was built after a

‡ Joſeph. Lib. VII. † Diod. Sicul. Lib. XX. * *This nearly anſwered to what we now underſtand by a* Battery.

Model

Model contrived by *Archimedes*, relates, † *That in this Ship they erected a Platform or Battery, from whence with their Engines they ſhot Stones of three Talents Weight, and at the ſame time a Spear or Javelin of* 12 *Cubits in Length, to the Diſtance of a Furlong.* This is very wonderful, and almoſt incredible; but I fear I begin to tire you with this Subject; and indeed, I think, I have here ſaid enough, to inform you of the Weights and Diſtances which the *Baliſtæ* formerly carried, and to ſhew that the Things ſhot from them were very near equal to our greateſt *Grenado's* or *Bombs*, and if I had affirmed them to have been much larger and heavier, I believe I ſhould not have exceeded the Bounds of Truth. We ſhall take a proper Opportunity of treating at large on the Uſes and Conveniencies of theſe Machines, where we ſhall make it appear, that it would be very proper to introduce them into Modern Practice with our other *Engines*.

CHAP. II.

Of Bombs *and* Grenado's *that are uſually projected from* Mortar-Pieces.

IF we conſider the greater Sort of *Grenado's* in point of Form, we ſhall find them to be of two Kinds, (*viz.*) Round, and Spheroidical; which laſt we commonly call *Bombs*. Though *Boxhornius*, in his Hiſtory of the Siege of *Breda*, calls thoſe alſo *Bombs* that are of a Spherical Form; for he mentions them in theſe Terms, after having deſcribed the *Hand-Grenado's*. Bombs *of the largeſt Sizes that were one or two Foot Diameter did the ſame Execution, They were ſhot into the Air from Engines, and fell upon the Places they were deſigned for.* But if I am not miſtaken, he here confounds the *Grenado's* with the *Bombs*; for he in another Place ſays as much of *Grenado's* as he does here of *Bombs*, (viz.) *They were obliged to erect Batteries at various Diſtances from the Counterſcarps; according as the Exigence of Affairs required, either to cover their People, or ſtop the Sallies of the Enemy, to ruin their Machines, demoliſh their Batteries, and diſmount their Cannon. That upon the Batteries they erected, they mounted more or leſs Artillery with ſome of thoſe Machines (meaning* Mortars) *from whence they ſhot* Grenado's, *which burned and threw down every thing within their Reach.* (He then diſtinguiſhes theſe from the *Hand-Grenado's*, by ſaying) *That the lighter and leſſer Sorts were thrown by the Soldiers.* As an Hiſtorian, I do not diſapprove of what he here ſays; (the true Knowledge of theſe Matters being reſerved for *Pyroboliſts;)* I ſhall only obſerve that moſt *Pyrotechni-*

† Athen. Lib. V.

cians

cians call those Balls that are Hollow and Spherical, *Grenado's*; and that those which are Longish and Oval, they call *Bombs*.

Fig. 113. You have these round *Grenado's* represented in *Fig.* 113, and the long
Fig. 114. ones in *Fig.* 114.

To these two we have added a Third of a Cylindrical Form, which
Fig. 115. you have in *Fig.* 115; it has a firm Tompion beneath, which serves to press down and confine the *Powder* in the Chamber of the *Mortar*, in the same manner as the Tompions which are commonly used on those Occasions do. It is not long since these *Grenado's* were put in Execution; for some of those who were present at the memorable Siege of *Rochelle*, in the Years 1627 and 1628, by *Louis* XIII. King of *France* and *Navarre*, have related to us the strange Havoc they made, and how greatly they annoyed the Besieged: All which was ascribed to the great Knowledge and Skill of the worthy *Henry Clarmer* of *Noremberg*; to whom no Body can deny one of the first Palms, deservedly bestowed on the Heroic Warriours, who wrought such Wonders at that remarkable Siege, without doing the least Injustice to the Merits of *Pomponius Targon*, who was at that time chief Engineer to his most Christian Majesty.

But there have been some odd-turned Spirits, who have had Impudence enough to rob those great Men of the Honour they atchieved in the Conduct of so long and so laborious a Siege, and who have endeavoured (urged by an unaccountable Envy) to ascribe to themselves what was due to those illustrious Persons; and they have so far gained their Point, as to insinuate a good Opinion of themselves into the Credulous and Ignorant, who esteem them to be in Reality what they only are in Appearance: But a time will come when they will receive a Chastisement adequate to their Unworthiness; for Divine Justice leaves no Crime unpunished, and will certainly take Vengeance of them for their fraudulent Dealing; in so ungenerously assuming that to themselves, which had been purchased by others at so dear a Rate. But let us return to our Subject, and consider after what manner we are to proportion, prepare, and use the two First Sorts of *Grenado's*.

There are those who allow the Thickness of Metal, for *Iron Grenado's* and *Bombs*, $\frac{1}{8}$, $\frac{1}{9}$, or $\frac{1}{10}$ of their Diameters. The Vent ought to be $\frac{2}{9}$, as well for these as *Hand-Grenado's*. Near the Vent they have two Ears or little Handles, by which they are lifted into the *Mortar*.

The Fuze of the said *Grenado* shall be $\frac{7}{8}$ of its Diameter in Length, though some *Pyrobolists* allow it but $\frac{6}{8}$ only. Its Diameter at Top shall be $\frac{2}{9}$ or $\frac{2}{10}$, but beneath it shall be but $\frac{1}{8}$ only. The Depth of the Concavity in the Fuze shall be $\frac{1}{16}$ of the same Diameter, as usual; you
Fig. 116. have this Fuze represented in *Fig.* 116. But the whole Mystery is to know of what Dimensions to bore the Fuzes; for there is a certain limited Time, at the Period of which the *Grenado* is to perform its Effect, according to the Distances of Places, and according to which the

Mortar

Mortar is elevated to different Degrees of the Quadrant. It is moreover neceſſary to know with what *Compoſition* the Fuze ought to be filled upon different Occaſions, that the Shell may not break till it is very near the Ground. But as this is an improper Place to dwell upon theſe Particulars, which bear an immediate Relation to the Artificial Conſtruction and Uſe of our *Warlike Machines*, I ſhall reſerve what I have to ſay of them for the *Second Book* of the *Second Part* of our *Artillery*, where I ſhall in the moſt ample manner diſplay the Conſtruction of *Mortar-Pieces*, their Properties, and particular Uſes: And if it be the Will of Heaven, I ſhall produce ſufficient Arguments in Behalf of every thing I lay down, and ſhall make it my utmoſt endeavour by no means to deceive our diligent *Pyroboliſt*: But let us proceed to the Sequel of this Eſſay.

Theſe Fuzes ſhall be re-inforced without, with dried Sinews, ſpread out like Tow, then ſteeped in hot Glue; and within them you ſhall ſtick ſome Threads of *Quick-Match* here and there, for fear the Fuze ſhould unluckily go out, by the Violence of the Wind or Air during the Flight of the *Bomb*: In ſhort, the Fuze being filled with a ſutable *Compoſition* (ſuch as we gave in the foregoing Chapter) you ſhall drive it into the Vent of the *Grenado* or *Bomb*, which muſt be filled with good *Corn Powder*, in the ſame manner as we directed in reference to *Hand-Grenado's*.

Obſerve here, that you muſt never uſe a Shell till you have tried whether it be ſound and whole, which you may know by the following Proof: Bury your Shell under burning Coals to make it red-hot; and having acquired that degree of Heat, take it from under the Fire, and pour cold Water into it before it is cooled, and ſtop up the Vent, to prevent the Water from getting out; then inſtantly anoint the whole Convexity of the Shell with Butter of *Antimony*, or with Soap moiſtened with a little hot Water; if it is cracked or defective in any Part, you will ſee little Bubbles, or Bliſters, riſe, fall, and diſappear by turns. If you perceive any thing of this Nature upon the Surface of your Shell, I would have you throw it aſide if you have any better, as both uſeleſs and dangerous: But if the Situation of your Affairs obliges you to uſe ſuch, for want of better; you ſhall take particular Notice of the Cracks or Flaws if they are viſible, and if not, you ſhall remark thoſe Places where you ſaw the Bliſters riſe; or if they are little Holes that are conſpicuous, you may ſtop them with Steel Nails. This done, coat your Shells over with Tar or Pitch, or ſome of our *Pyrotechnic Cement*, and then cover them well with Tow ſteeped in the ſame Stuff, the *Compoſition* of which we gave in the above Chapter. Finally, wrap them tightly round with a ſtrong Cloth. You muſt exactly obſerve theſe Particulars without omitting the leaſt thing in the World; for fear the *Grenado* ſhould meet with any Accident from the *Fire* of the Fuze during its Flight.

You may find the Requiſite of *Powder* for projecting your *Grenado*'s, by what I am now going to ſay: But firſt of all it will be neceſſary for me to tell you, how to come at the Weight of a *Grenado*, purely by the Aſſiſtance of an *Arithmetical Calculation*, and by means of our *Calibre Scale*, which is the moſt ready Step towards finding expeditiouſly and certainly the Quantity of *Powder* requiſite to ſhoot out your *Grenado*. This you may work after the following manner.

Take the Diameter of a *Grenado*, and apply it to that Side of the *Calibre Scale* which is deſigned for *Iron Bullets*; and conſequently one Foot of the Compaſſes will fall upon a Number, anſwering to the Weight of the *Grenado* if it was ſolid. Set down this Number upon a piece of Paper, or at leaſt take care to remember it. Then take the Diameter of the Cavity of the ſame *Grenado*, and applying it in like manner to the *Calibre Scale*, one Foot of the Compaſſes will point out a Number expreſſing the Weight of that Cavity if it had been ſolid, and of Iron. Then ſubſtract this laſt Number from the firſt, and the Remainder will give you the Weight of the Shell of the *Grenado*.

If you ſhould meet with a Diameter which extends beyond the Length of the *Calibre Scale*, you ſhall apply the Half of it only to the ſaid *Scale*, and the Number it reaches to being multiplied by 8, the Product will give you the Weight of the whole *Grenado* had it been Solid. As for Example; be there given the Diameter of a *Grenado* that cannot be meaſured by the Extent of the *Calibre Scale*; the Half of which being applied to the ſaid *Scale* reaches to 18: This Number being multiplied by 8 will produce 144, which would be the Weight of the *Grenado* had it been ſolid: Then taking half the Diameter of the Hollow or Cavity of it, and applying it to the *Calibre Scale*, ſuppoſe it to extend to 7: Let this Number be in like manner multiplied by 8, and it will produce 56. In ſhort, this laſt Number being ſubſtracted from 144, you will have a Remainder of 88, for the Weight of the Shell of your *Grenado* or *Bomb*.

You will find the Quantity of *Powder* neceſſary to fill your *Grenado*, if you meaſure the Cavity of it with a certain Line or Scale of *Powder*, *Stereometrically* divided into *Pounds* and *Ounces*, ſuch as you ſee diſtin-
Fig. 117. guiſhed by A in *Fig.* 117; upon which the Number which falls under the Foot of your Compaſſes, will expreſs the Number of *Pounds* or *Ounces* of *Powder* which the Cavity of the *Grenado* is able to contain; add now this Weight of *Powder*, to the Remainder of the laſt Subſtraction, which gave the Weight of the Shell, and you will have the whole Weight of the *Grenado* when filled with *Powder*. I will now inſtruct you in the Conſtruction of this *Scale*. Fill ſome perfectly round *Grenado* with *Corn Powder* up to the Vent, then pour it out again, and weighing it, ſet down what it weighs. Then meaſure the Cavity of the ſaid *Grenado*, and divide the Diameter of it *Stereometrically* into as many Parts as the *Powder* contains *Pounds* or *Ounces*: This you may readily

readily do by obſerving the Rules in our Firſt Book; and upon ſuch a *Scale* you may mark out the Diameters of ſeveral *Pounds*, or *Ounces* of a *Pound*, or half *Ounces* if needful.

But if you ſhould not have *Grenado's* juſt at hand, whereby to form this *Scale*, get an hollow Wooden Cylinder of what Size you pleaſe equal in Height and Breadth, and filling it with *Corn Powder*, pour it out again, and weigh it. Now as every Cylinder that contains a Sphere is in a *Seſquialteral Proportion* to it, according to *Archimedes*: Therefore muſt you ſay as 3 is to 2, ſo is the Weight of the *Powder* contained in the Cylinder, to the Weight of that which would be held by a Sphere, included in the ſame Cylinder. This done, you will have a Number in your Quotient anſwering to the Weight of a *Globe* of *Powder*, ſuppoſing the Diameter of ſuch a *Globe* to be equal to the Height and Breadth of the Cylinder. This may be done by any Body, that is never ſo little skilled in *Geometry*.

Sometimes *Pyroboliſts*, by way of Diverſion or Experiment, fill *Grenado's* with Sand, thereby to come the more eaſily at their true Weight: Which done, they put them into *Mortars*, and taking their Sight at Marks at certain Diſtances; they ſhoot them off, and obſerve their Falls: Upon which Account it is neceſſary to know the Proportion which the Weight of *Sand* bears to that of *Powder*. For my part, I have often experimented that very Fine, White, Dry Sand, bears ſuch Proportion to fine *Corn Piſtol-Powder* as 144 does to 83. Upon this Foundation I have formed another *Scale* which you ſee diſtinguiſhed by B for *Globes* of *Sand*. By this Line you may know how many *Pounds* of Sand would fill each *Grenado*. But if you would take only juſt ſo much Sand as is equal in Weight to the *Powder* which fills the *Grenado* (in which *Pyroboliſts* are very exact) you muſt find out the Quantity required by means of the proportional Numbers above: But that *Ratio* will not always obtain; for the Weight both of *Powder* and of *Sand* may be infinitely varied; for as the *Ingredients* of *Gun-powder* are mixed a thouſand ways, you may readily ſuppoſe that it differs much in Weight; and on the other hand, the ſeveral ſorts of Sand are infinitely unequal in point of Gravity: But thoſe who are deſirous of being perfect in our *Art*, will have the Patience to examine the Gravity of different Sorts of Sand. Having ſhewn you the way how to come at the Weight of *Grenado's* filled both with *Powder* and *Sand* (as I propoſed) without the help of any weighing Inſtrument; I ſhall advance farther on. Fig. 117.

Now this Weight being found, it will be very eaſy to find the Requiſite of *Powder* for charging your *Mortar*. But to ſay the Truth, this is a Point which cannot well be determined; for *Pyroboliſts* change and vary it very often, as Occaſion requires; being obliged ſometimes to take more, ſometimes leſs *Powder*, according to the Diſtances of Places. Moſt commonly they take half an *Ounce* of *Powder* for every *Pound* that the *Grenado* weighs; and in ſome Caſes they take but a Quarter of an

Ounce,

Ounce, and at other times but $\frac{1}{2}$ of an *Ounce*, and ſometimes leſs, particularly when they would project their *Grenado's* ſo as not to be above 4 or 6 Seconds at moſt before they fall at perhaps the Diſtance of 10 or 15 Paces, and in their Projection borrow more upon a ſtrait Line than a Curve. This is uſually done when the Beſieged ſee the Enemy preparing to make their Galleries, or perceive them obſtinately bent upon paſſing the *Foſſé*, by any other means, in order to gain the Foot of the *Rampart*; it is then that the Uſe of *Mortars*, *Grenado's* and *Bombs* is not forgot. I muſt own however, that the ſame thing may be done with a greater Quantity of *Powder*; but then it would be attended with this Inconveniency (namely) That the *Grenado* being projected with the greater Violence, it would be obliged to go through a greater Space, and conſequently remaining longer in the Air, it would give thoſe who ſee it, time to get out of the Danger of it before it can fall. I muſt alſo remark, that you may throw *Grenado's*, *Bombs*, &c. at ſeveral Diſtances with one and the ſame Quantity of *Powder*; by means of the Elevation of the Piece above the Plane of the *Horizon*, and alſo by the Declination of it from the Vertical Point or Zenith to an Angle of 45 Degrees, which Poſition is the moſt natural to *Mortars*. This may not be an improper Hint; for I am really of Opinion, it would be by much the beſt and moſt certain (were it not for ſome inſurmountable Difficulties and Circumſtances which oppoſe it) to take certain Quantities of *Powder* in proportion to each Diſtance; by which means the *Machines* being elevated but a few Degrees above the *Horizon*, would always have their Poſition very low, which would be never, or very ſeldom changed. However as this cannot be eaſily practiſed, or indeed not at all, for every Diſtance; yet methinks I would have the great *Machines*, whoſe Elevations borrow the neareſt upon the Vertical Point, and which are uſually choſen for the ſhorteſt Diſtances, deprived of a little of their uſual Requiſite of *Powder*, and in Recompence for that Loſs, inclined a little more to the *Horizon*.

But not to ſtop here, and that we may conclude upon ſomething certain with regard to the Requiſite of *Powder*; I have eſtabliſhed and aſcertained a Quantity, that may generally ſpeaking diſlodge the *Military Projectiles*, be their Weight what it will: In order to this, I have conſtructed a little *Table* of *Requiſites* (which we ſhall dwell more particularly upon in the Second Part of our *Artillery)* which I hope may be ſucceſsfully put in Practice. I ſay it will be ſufficient if for *Balls* or *Bombs* of great Weight, as 300 ℔ or more, (if there are any ſuch,) you take half an *Ounce* of *Powder* for every *Pound*. This Proportion may be obſerved for *Projectiles* down to 100 ℔: But from 100 ℔ to one ℔, you ſhall increaſe every Quintary that is every Fifth Number with 15 *Grains*; ſo that you may have 588 *Grains* of *Powder*, which are 2 *Loths* and 12 *Grains*, to project a *Ball* of one ℔. Upon this Foundation I have calculated a little *Table* of *Proportion*, from 100 ℔ down to one ℔.

There

Fig. N.° 102.

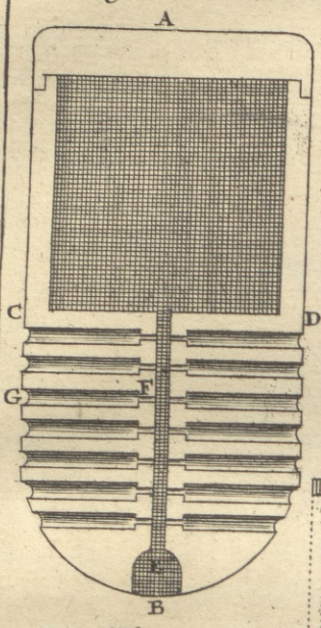
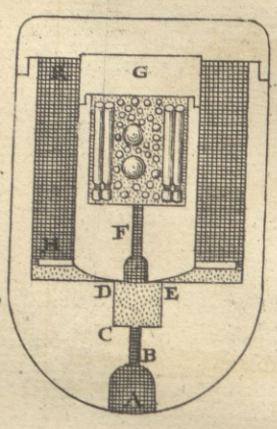
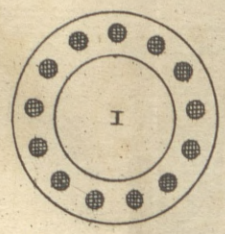
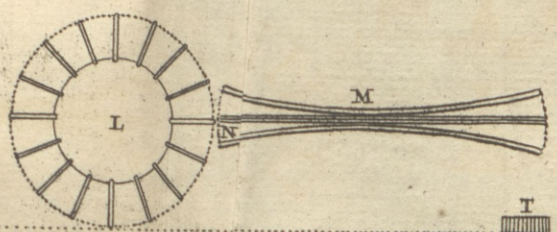


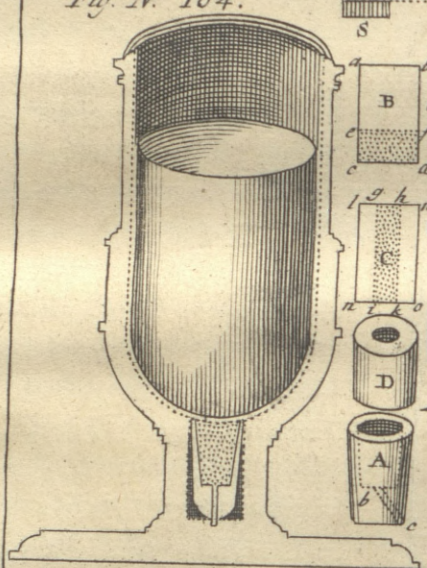
Fig. N.° 104.

Fig. N.° 103.









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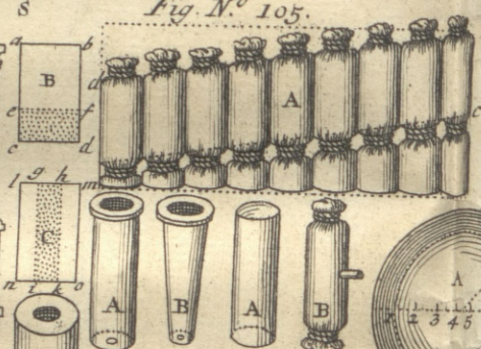
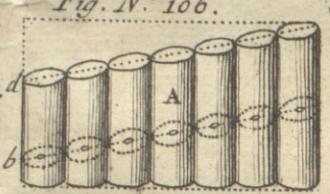
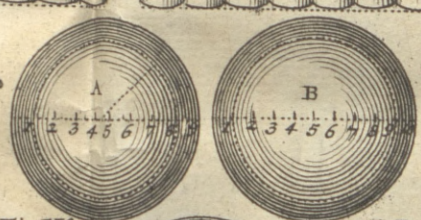


N.° 107. N.° 108.

Fig. N.° 106.





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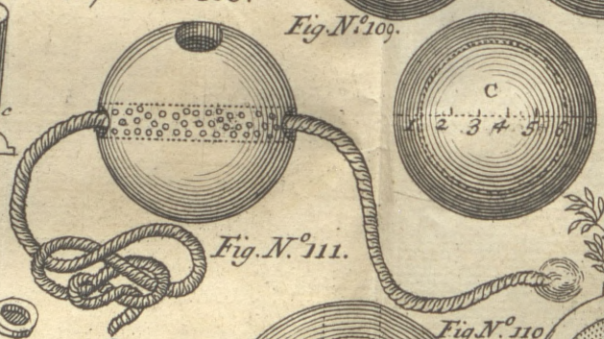

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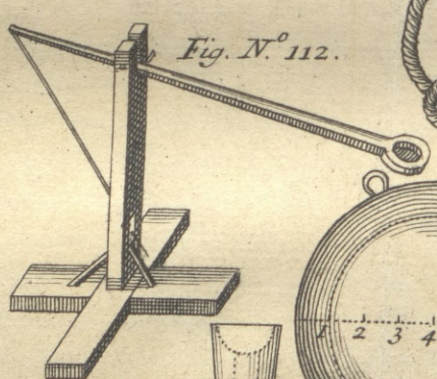

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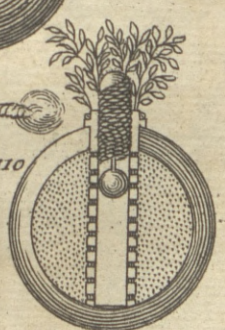

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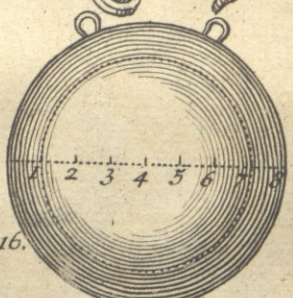

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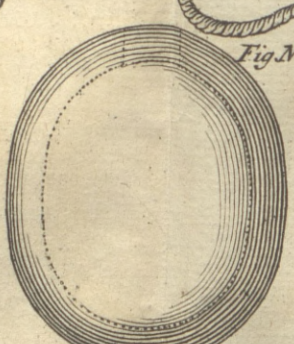
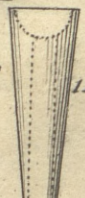


Fig. N.° 114.

Fig. N.° 116.



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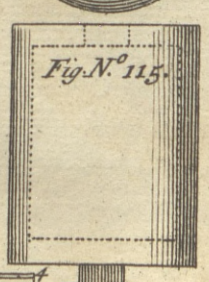

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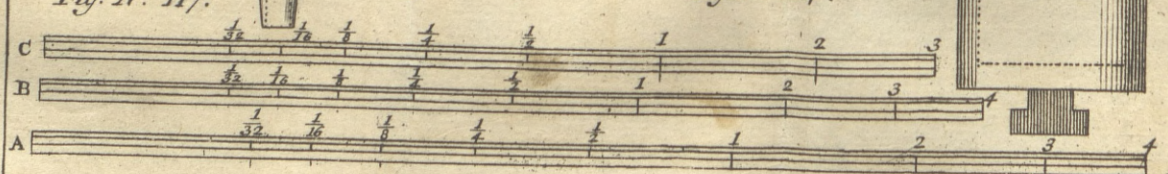

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There is nothing that can be more plain or eaſy than the Uſe of it; for you need only multiply the Numbers of the Column B by the Numbers of the Column A, and divide the Products by 288 in order to have the Requiſite Number of *Loths*; (for a *Loth* contains juſt that Number of *Grains*;) which Number of *Loths* being divided by 32, you will have the *Pounds*: But that you may have a perfect Apprehenſion of this, I ſhall illuſtrate it by an Example. Suppoſe you have a *Ball* of 80 ℔ which you would project: Look firſt for 80 in Column A; and having found it, multiply it by the oppoſite Number in Column B (*viz.*) by 348, and you will have a Product of 27840; which will be the Number of *Grains* of *Powder*; which being divided by 288, will give 96 *Loths* 8 *Den.* in the Quotient; each *Denier* 24 *Grains*. In ſhort, theſe *Loths* being divided by 32, will give 3 ℔. You muſt then take 3 ℔ and 8 *Deniers* of *Powder* to charge the Chamber of the *Mortar*, from which you would project a Body weighing 80 ℔.

The following *Table* will help you in the Difficulties which may occur in this Caſe; provided that you have a right Conception of this Example.

A TABLE *of Requiſites of* Gun-Powder.

A	B
100	288
95	303
90	318
85	333
80	348
75	363
70	378
65	393
60	408
55	423
50	438
45	453
40	468
35	483
30	498
25	513
20	528
15	543
10	558
5	573
1	588

OBSERVATION I.

To every Number between the Quintaries of this *Table*, you ſhall ſucceſſively add 3 *Grains* for every *Pound*. This done, multiply the Sum of that Addition by the Weight of the *Projectile*. As for Example, if you meet with one that weighs 82 lb, you will find it leſs by 3 than 85, the ſuperior Quintary of the *Table*; having then added 9 (which is 3 for each *Pound*) to 333, you will have 342; this 342 being multiplied by the Weight of the *Projectile* which is 82, the Product will be 28044; which being divided by 288, you will have 97 *Loths*, 4 *Deniers* and $\frac{1}{9}$.

OBSERVATION II.

The Rule here laid down for the *Projectiles* which are ſhot from *Mortars* ought to be followed as univerſal and immutable: But at the ſame time Allowance muſt be made for the different Strength of *Powder*; inaſmuch as one *Ounce* of ſome ſort of *Powder* will do twice, nay, ten times the Service as an equal Quantity of ſome other Sorts; and conſequently one *Ounce* of the former will be as ſtrong as 10 *Ounces* of the latter. But I leave this Article to the Conſideration and Judgment of good Practitioners; and ſhall go on to the loading of our *Mortars*.

Suppoſe now, you have the Requiſite of *Powder* for projecting a *Grenado* from a *Mortar*: You ſhall in the next place meaſure the Height and Breadth of the Chamber by means of a *Cylindric Scale*, or rather a *Cylindro-metric Scale*, divided Cubically, and adjuſted to the Weight of
Fig. 117. *Gun-powder*, ſuch as you ſee in *Fig.* 117 in the Letter C. Now if it happens that your Chamber is equal in Height and Breadth, you may conclude that it holds as many *Pounds* of *Powder*, as the Number it cuts upon your *Scale* contains Unities: But if on the contrary its Height and Breadth are different, you muſt find out a mean Proportional between them, which may give you the true Capacity of the Chamber. If theſe Numbers ſhould happen to be Surds, you may find out a mean Proportional between them by Lines much better than by Numbers.

If the Chamber of your *Mortar* is bigger than neceſſary; firſt put your *Powder* into the Chamber, and meaſure the Vacancy of it above the *Powder*: Divide this into 6 equal Parts, and add $\frac{1}{6}$ to its Height; and you will have the true Height of a Wooden Tompion; by which the *Powder* in the Chamber will be ſufficiently compreſſed, ſo that the Flaſh will have no room to expand itſelf, and will conſequently act with its full expulſive Vigour: But if on the contrary the Chamber of your *Mortar* is too little to hold the Requiſite of *Powder*; divide the Height of it into 10 equal Parts, and fill it up with *Powder* to $\frac{9}{10}$, and ram it with a Tompion of $\frac{1}{10}$. And in this Caſe the Rule we have given above can be of no Uſe.

You

You muſt proceed after this manner when it happens that your *Powder* fills your Chamber ſo exactly as to leave no room for a Tompion; but you will be better inſtructed in every thing relating to this matter by the Sequel.

The Wooden † Tompions for confining the *Powder* in the Chambers of *Mortars* are prepared after different Faſhions; for if you would fix your *Grenado* in ſuch a Poſture as to have its Fuze turned outwards towards the Muzzle of the *Mortar*, and if you would project it by one Fire only, your Tompion ſhould be fluted like a Pillar, as you may obſerve in *Fig.* 118 by the Letter A; or pierced through with Holes at Top which terminate in a large one at Bottom, as may be obſerved in B. I muſt here remark, that it is by much the ſafeſt Way, to project your *Grenado's* by means of one *Fire* only; in doing of which you are to obſerve the following Order. Fig. 118.

After having loaded your Chamber with the Requiſite of *Powder*, and driven the Tompion upon it, ſo as in no degree to ſurmount the Edge or Rim of the Chamber; you ſhall fill up the Holes in the ſaid Tompion, or the Flutings round it, with good *Meal Powder*, and ſalt it over with a good handful of the ſame; then wrap up your *Grenado* in a Felt, or a coarſe Woollen Cloth, well ſoaked in ſtrong Brandy, mixed with *Meal Powder*; this Coat or Covering ſhall be open at Bottom, of the ſame Breadth as the Orifice of the Chamber. This done; fix your *Grenado* in the *Mortar* in ſuch manner as to bear upon the Tompion.

The Fuze ſhall be well garniſhed round, with ſome of our looſe *Quick Match*; and the whole Body of the *Grenado* ſhall be well ſalted over with *Meal Powder*, to facilitate the Accenſion of the Fuze.

This is the firſt Way of projecting *Grenado's* from *Mortars* with one *Fire* only. The Second does not differ much from it, excepting that it is much the more dangerous of the two; for here the Fuze is turned inwards upon the Chamber; and in this caſe you muſt have a Tompion with an Hole in the Middle of it, and divided into 4 equal Parts by means of two Diameters interſecting each other at Right Angles, as you ſee in *Fig.* 118 by the Letter C. However I would by no means have this practiſed for ordinary *Grenado's*: But I would have them ordered as you ſee in *Fig.* 119, where the Vent and Bottom are turned into Female Screws, which ſhall have an Iron Fuze with a Screw at Top and Bottom to be inſerted into them, as may be ſeen in A: But I muſt tell you that theſe Screws cannot be too nicely fitted to each other. Fig. 119.

If you would rather chuſe to project your *Grenado* by means of two *Fires*, you ſhall have a ſolid Tompion. This Tompion being driven into the Chamber, you ſhall cover it with a freſh green *Gazon* or Turf, or ſomething of that kind, which ſhall be covered with a round Board of 2 or 3 Inches thick, but a little leſs in Diameter than the Calibre of

† Theſe Tompions are found to be uſeleſs;

the

the *Mortar* (ſee Letter D.) To conclude, you ſhall fix your *Grenado* upon it with its Fuze turned outwards, and cover it with a *Gazon*; after having ſtuffed the Vacancy between the *Shell* and the *Mortar* all round with Hay, Straw, Tow, or Mold, to keep the Shell fixed and firm. Fig. 120. This laſt Method is very particularly repreſented in *Fig.* 120, to which I refer you, if you do not apprehend my Explanation.

COROLLARY.

To tell you now who firſt invented, or who firſt practiſed this deſtructive Contrivance, which has been promiſcuouſly the Ruin of ſuch Numbers of Men, and the Overthrow of ſo many of the moſt beautiful Buildings, moſt magnificent Cities, and ſtrongeſt Walls and Fortifications in the World, is a Task unequal to my Knowledge; for we do not find the leaſt Mention made of the Perſon in any Hiſtory. Indeed in ſeveral reputable Authors we have an Account of the Times and Places, when and where this infernal Invention was firſt put in Practice; the Teſtimony of whom I ſhall here inſert, notwithſtanding that they differ pretty much from one another. But as to the Inventor himſelf, we do not find the leaſt Mention made of him; which I cannot help being ſurprized at, ſince it ſeems to be a very great Injuſtice to Poſterity to conceal the Name of ſo great an Engineer from it. In truth, I know not what to ſay or think of ſuch a Procedure, and ſhould be glad to know whether it was thro' Chance or premeditated Deſign, that the Writers of thoſe Times have left us in the dark as to this Matter: But every one may judge of it as he pleaſes, for my part, I can only here entertain ſuch as are wholly Strangers to the Hiſtory of this Invention, with what can be gathered from the Teſtimony of ſeveral Authors. *Thuanus* ſays,

† *All the Stratagems of the Duke of* Parma *before* Bergen op Zoom *proving ineffectual, and deſpairing to carry it, and conſidering that the Seaſon was very far advanced, and that the* Low Country *was almoſt overflowed; and finding that the Garriſons of the Iſland of* Tretole, *by their continual Excurſions and Depredations, made Proviſions very ſcarce and dear in his Army, he reſolved to raiſe the* Siege, *and ſend his* People *into Winter Quarters, and accordingly he diſtributed ſome of his Troops in* Turenhalt, Roſendal, *and the Country of* ‡ Campen, *and ſent the reſt to join the Troops which were under the Command of* Prince Erneſt Mansfelt *at the Siege of* Bon, *to block up* Watchtendonck, *which is an ancient Town of the* || Sicambrians, *ſituated upon the* Niers *not far from the City of* Gueldres. *This was done, at the earneſt Entreaty of the Inhabitants of* Ruremond, *who begged to be delivered from the troubleſome Excur-*

† Thu. Lib. LXXXIX. Pag. 263. A. D. 1588. ‡ This is now moſt commonly called *Zutphen*.
|| The People of *Gelderland* were anciently ſo called, and the Country itſelf was called *Sicambria*.

ſions

ſions of the Robbers (*it was thus they called the Soldiers of the neighbouring Garriſons.) Towards the end then of* October *the Place was inveſted, under the Conduct and Command of the aforeſaid* Mansfelt. *The Pioneers advanced and raiſed Batteries of* Gazons *or* Sodds, *upon which they mounted their Cannon, which played upon the Town till they threw down the Roofs of the Houſes, and all the lofty Buildings in it. But they did not only* (ſays he) *ruin them with their Cannon, but they alſo galled them with* Grenado's *and* Balls *filled with combuſtible Matter, which they ſhot among them with certain Engines, ſo that the poor People could hardly find Safety any where, from the horid Tempeſt which was ſhowered down upon them.* He adds, *That theſe* Balls *were made hard by, at a ſmall Town called* Venlo; *and that the* Inventor *of them, reſolving to make Proof of his Work, at the Celebration of a Feſtival deſigned for the Entertainment of* William *the young Prince of* Cleves, *he had no ſooner ſet Fire to them, than they had an Effect quite contrary to what he intended; for the* Town *was fired by them, and was very near half deſtroyed.* A melancholly Diverſion!

This Author has hitherto pretty well informed us of the Place where our Miſſive Thunder was invented, and of the Time it was firſt put in Execution. But another Writer, who equally deſerves our Credit, (namely) *Reidanus*, who has left us the Hiſtory of the *Low-Country Wars* in *Latin*, ſeems to be of a quite contrary Opinion as to this Point. He ſpeaks thus: † Adolphus Nivenarius, *Governor of* Guelders, *reſolved to keep up the Scarcity of Proviſion as much as he could, and to ſtarve the Inhabitants of* Bergen, *if poſſible. But unhappily as he was proving his* Bombs, *with which he had determined to deſtroy the Enemy's Ammunition, he was greatly aſtoniſhed, to find that upon being fired they blew up the Arches and Vaults of the Caſtle of* Harnem, *together with ſeveral other fine Buildings. A brave Officer called* Denis, *and another Gentleman, periſhed by this Accident: And the* Earl *himſelf could not eſcape the Fire, for being cruelly burnt, he died a few Days after. Almoſt ſuch another Accident happened the Year before,* (he means 1587) *at* Bergen op Zoom; *but of a more extraordinary nature. A certain* Italian *who deſerted from the Duke of* Parma, *fled to the* Confederates, *to whom he pretended, that he had an admirable and un-heard of* Invention *for preparing hollow Veſſels and Globes of Iron and Stone* (ſure this was a thing impracticable, and I believe every *Pyrotechnician* will think it impoſſible to contrive ſo as to make *Stone* effectual in ſuch Works: But he goes on) *which might be eaſily thrown amongſt the Enemy; where they would do moſt terrible Execution by Thouſands of Splinters, which would fly from them in burſting, and beſides, that the leaſt Spark of them would infallibly ſet fire to whatever they touched. But the Inſtant that our Grenadier was buſied in carrying on his Project, a Spark of Fire unfortunately fell upon the Table where he had prepared his* Compoſition; *and as he was going*

† Reid. Lib. VIII. Page 182.

haſtily to take it away, the Fire (which loſes no time) got hold on his Hand. He, aſtoniſhed to ſee a Glove of Flame upon his Hand, and not knowing what to do to get rid of it, clapped his Hand between his Thighs to ſtifle it, but far from being ſuppreſſed it laid hold on his Breeches, and from thence penetrated to his Thighs: In a Word, his Hand was inſtantly ſtript of both Skin and Fleſh. Vinegar proved ineffectual, and inſtead of extinguiſhing rather increaſed the Flame; to conclude, the Fire ſpreading over the reſt of his Limbs, the unhappy Man expired in leſs than three Days, after having ſuffered the moſt ſevere Pains without Intermiſſion or Relief.

To the Teſtimony of theſe two grave Authors, I ſhall add that of a Third, whoſe Fidelity is unqueſtionable, I mean *Famianus Strada*, who ſpeaking of the *Low-Country* Wars, writes to this Effect, † *There was nothing which more aſtoniſhed the Enemy* (he here means the Attack of *Mansfelt* at *Wachtendonck*) *than certain great Braſs Globes hollow within, which were filled with* Powder *and* Sulphur, *and other inextinguiſhable Things; which were ſhot from great* Mortars, *with little* ‡ *Ropes in a ſmall Hole, which by their Weight, and Violence of their Fall, threw down the greateſt part of the Buildings; and what is the moſt ſtrange of all, when they were lighted their Flame caught hold on every thing within its reach, with ſuch Obſtinacy that no Water could extinguiſh it. Theſe* Globes, *which gave the firſt Hint to the Invention of* Grenado's, Fire-Pots, *and ſuch like Inſtruments of Death, were invented (as we are told) by a Man at* Venlo *a little before the Siege of* Wachtendonck; *though he happened to be the Deſtruction of his own Town: For upon a Day that the Inhabitants of* Venlo *made an Entertainment for the Duke of* Cleves, *this conſummate* Artiſt *making Experiment of his new Invention to divert that* Prince, *ſhot off one of them, which falling upon a large Building, broke down through it from Top to Bottom, and ſetting it in a Blaze, the* Fire *ran over all the Neighbourhood, ſo that in a very little time two Thirds of the* Town *were laid in Aſhes. I know a certain* Author (he means *Reidanus) who in his* Hiſtory *relates ſomething of this Kind to have happened a Month or two before at* Bergen op Zoom, *to an* Italian Deſerter, *who was going to make an* Experiment *of one of theſe* Balls. *This* Renegade *promiſed the* Confederate States *to make certain hollow* Veſſels *or* Globes *of Iron or Stone, which being kindled, and thrown into beſieged Places, ſhould ſet Fire to whatever they could reach; after having broke into a thouſand pieces. But by a ſtrange* Miſhap, *a Spark of Fire fell upon the* Compoſition *he had prepared for theſe* Globes, *and the Flame of it caught hold on him in ſo frightful a manner, that ſpreading all over him from one Limb to another, he died moſt miſerably, after having undergone the moſt exquiſite Torment; and left it doubtful, whether or no he would have come up to what he promiſed. But however that might be, it appeared that thoſe* Venlovian Engines *an-*

† Fam. Stra. Lib. X. Decad. II. ‡ This ſeems pretty obſcure; but perhaps inſtead of Fuzes, they ſtuck ſome ſort of Match in the Vents of their *Grenado's* or *Bombs*.

ſwered

ſwered very well to the Purpoſes of Mansfelt; *for with them he committed ſuch mercileſs Ravages, demoliſhed ſo many fine Buildings, and killed ſuch vaſt Numbers of People in the Places he beſieged, that the* Inhabitants *could hardly find Shelter from the* Tempeſt, *which continually purſued them where-ever they went, though they retired to Cellars and the moſt ſubterraneous Retreats. The Burgeſſes of the* Town *at length conſidering that this* Storm *of Iron and Fire, threw them into the utmoſt Confuſion, and perceiving that it demoliſhed all their Habitations, and that they ſhould inſenſibly loſe their Country, reſolved to go in a Body to* Lancteir *their Governour, to beſeech him to take ſome Meaſures towards the Preſervation of their* Lives *and* Fortunes, *and to deſire him to reflect ſeriouſly upon their unhappy State. Upon the whole, they alledged that they were utterly deſtroyed by degrees; that they had but few Buildings left ſtanding; and added, that if the* Enemy *continued to ply them with their* Grenado's, *it would be impoſſible for them to ſubſiſt, or make any farther Reſiſtance, except they built a new* Watchtendonck *under Ground, as they had already begun.*

I muſt confeſs that what I have quoted from this Author, is a little foreign to the Point in hand: But he has expreſſed himſelf in ſo moving a manner of this dreadful Contrivance, that I could not help tranſcribing of him at length. It is from hence that the skilful *Pyroboliſt* may draw Concluſions in favour of theſe Weapons; it is from hence that he may perceive the Neceſſity there is for them in the Attacks of Places in our Times; in ſhort, it is from hence that he may judge of their great Utility to the Beſiegers, by compelling the Beſieged to a ſpeedy Capitulation, by expediting the Surrender of Towns and Cities, and diſtreſſing thoſe that are the moſt obſtinately bent upon defending themſelves.

Here I ſhould cloſe up this *Corollary*, as knowing that what I have quoted from theſe famous Hiſtorians has fully anſwered my Intention, which was to give an Account of the Origin of our *Grenado's*. But ſince in this Work I act the part of a *Pyroboliſt*, I think myſelf obliged to clear up every thing that may be obſcure in relation to the Practice of our *Art*, for the Benefit and Inſtruction of thoſe who particularly apply themſelves to the Cultivation of it. Let us then look back to what we quoted from *Famianus Strada*, where he has ſeemingly deſcribed the Form, the Properties and Effects of our *Grenado's*; and let us ask him what he means by the *Fire-Pots, Grenado's*, &c. which according to him derive their Origin from the hollow *Globes* he ſpeaks of, ſince his Deſcription of them agrees ſo nearly with that ſort of Arms which are now in Uſe with us. If he anſwers, that they were a ſort of *Balls*, which in his Time were called *Bombs*; (which Word I know is promiſcuouſly uſed to this Day) I ſhall reply, that the Word *Grenado* would have ſuited better with them, as being a more general Term. If on the other hand he alledges, that the little ones, which we call *Grenado's*,

are

are Deſcendants of thoſe great *Balls*; his Aſſertion will in ſome degree be falſely grounded; for I ſufficiently demonſtrated in the foregoing Chapter, that the ancient *Pyroboliſts* were acquainted with the ſmall *Grenado's*, conſiderably before they knew any thing of the Great. Thoſe who have the leiſure, may upon this Subject conſult *Leonardus Fronſpergerus* in the *Second Part* of his *Military Art*; which he dedicated to *Rodolphus* II, who was at that time newly elected King of *Hungary*, and who was afterwards Emperor of the *Romans* in the Year of our Redemption 1573. But though I ſhould grant that the leſſer ſort of *Grenado's* were unknown to paſt Times till after the Invention of the Greater, and that it was from Experience of the Nature of the Latter, that Men took it into their Heads to uſe the Former; yet I ſhall never allow that the *Military* † *Ollæ* or *Fire-Pots* are poſterior to the hollow *Globes* which he ſpeaks of, as he would have us believe. But very far to the contrary, I dare affirm that our *Grenado's* are derived from the *Fire-Pots*; and I make no ſcruple to ſay, that the *Ollæ* of the Ancients were the Lightning which preceded our Modern Thunder; and this I may ſafely advance, ſince I have the Teſtimony of ſeveral great Authors, who lived in unſpotted Credit and Reputation amongſt the Ancients, to ſupport me in it; from whom we may gather, that the moſt expert Captains in former Days met with very ſucceſsful Effects in their Sieges and Attacks from *Fire-Pots* not very unlike ours. We have elſewhere touched upon this, and therefore ſhall deſiſt from it at preſent, reſerving it till we come more particularly to ſpeak of *Fire-Pots*. In the mean time (dear Reader) let what we have offered be kindly received by you; and aſſure yourſelf, that *Artificial Pots* are of very old ſtanding, and that they are ſo far from deriving their Origin from *Grenado's* or *Bombs*, that it is more reaſonable to believe quite the reverſe. Pray hearken to what *Sextus Julius Frontinus* ſays of the *Fire-Pots* of the Ancients. ‡ Cneus Scipio, *in a Sea Fight found out a way of throwing* || Veſſels *full of* Pitch *and* Pine-wood *at the Enemy's Fleet, which were as dangerous in their Fall, becauſe of their Weight, as they were hurtful on the ſcore of the Igneous Nature of the Matter they contained which was ſpread abroad from them.* *Dionyſius* ſpeaking of the *Fireworks* which were uſed at the Battel of *Actium*, between *Auguſtus Cæſar* and *Marc Antony*, obſerves, * *That* Cæſar *perceiving his Soldiers very roughly handled by* Marc Antony's *Party, who cut them in pieces with their Axes and Swords, and galled them terribly with their miſſive Weapons, from the Advantage they had of being in taller and better-fortified Ships: He had recourſe to Fire, as the beſt Remedy he could apply to the prevailing Evil: In ſhort, his Soldiers gathered round him, and began to throw* Fire-Darts,

† This is only a *Latin* Word which ſignifies a *Pot* of any ſort.
‡ Sex. Jul. Fron. Lib. IV. Cap. VII.
|| The *Latin* has it *Amphoras*; but we muſt here conclude that *Frontinus* thereby means any ſort of *Veſſels* in general.
* Dion. Lib. L. de Bel. Act.

Brands

Brands *and* Torches, *together with* Pots *full of Pitch and burning Coals at the* Antonians, *which ſo annoyed them in their Ships (though they took care to keep as far out of Danger as they could) that the* Cæſareans *got the better of them. Thus what the Force of their Arms could not obtain, they effected by* Fire, *and thus by means of that Element they triumphed over their Adverſaries.*

I could bring ſeveral other Authors to bear witneſs in Favour of the *Fire-Pots* of the Ancients: But I apprehend that theſe two will be ſufficient to convince you of their Antiquity. Let us then proceed to the Conſtruction of ſeveral other Sorts of *Grenado's.*

CHAP. III.

Of Grenado's *that are commonly called* Blind.

PYROTECHNICIANS have certain *Grenado's* which ſtand in no Neceſſity of being lighted when they are projected, from whence they are called *Blind*, which is a common Term amongſt them, for ſuch *Grenado's* and other *Balls* as ſtand in no need of being fired at the time of their Projection: But as ſoon as theſe ſtrike the Ground, or fall upon any hard Subſtance, they have the ſame Effect as other *Grenado's*. *Fig.* 121 repreſents one of theſe *Grenado's*, in which the Letter A is the *Grenado*, hollow and pierced through and through, and which has on one Side another ſmall Hole, for the ſame purpoſe as thoſe in the other *Grenado's* which we have deſcribed above. Fig. 121.

Letter B in the ſame *Figure* points out a Barrel or Tube, made of an Iron Plate, whoſe Sides are full of Holes, and its Inſide made rough like a File. This Barrel receives two Flints which are ſcrewed tight in Contrivances like the Cock of a Gun-lock, which are ſoldered to a ſubſtantial Iron Rod, as may be ſeen in C. Firſt then, this Barrel muſt be fixed in the Shell; its upper End paſſing through the *Vertex* or Top of the *Grenado* where it is ſcrewed faſt with a little ſquare Plate of the Thickneſs of 2 or 3 Lines only, as you ſee in G. The lower end of the Barrel which receives the Flints ſhall reſt upon a round Plate with an Hole in the Middle of it, as you ſee in E, to keep it fixed in its Poſition. Now the Iron Rod that has the Cocks of the Flints ſoldered to the upper End of it, ſhall have its lower Extremity turned into a Screw, to fit a female Screw in the Middle of a large round Iron Plate, as you ſee in D, which ſerves for a Foot to the *Grenado* and all its Furniture, and upon which it falls when it comes to the Ground.

The Letter H ſhews you a ſingle moveable Cock with its Flint, ready to ſtrike Fire, and mounted upon a Steel, which may ſerve as well as the two former.

If you would ſee this *Grenado* as it is compounded of all its Parts when ſet together, caſt your Eye upon Letter K, where you will ſee it juſt as I have deſcribed it. You will moreover ſee two ſmall Tails above, to ſerve it inſtead of Wings, which are made of old pieces of Linen, drawn through two ſmall Irons, which are faſtened to the Rings on each Side of the ſquare Plate G; the Uſe of them is to make the *Grenado* fall in a perpendicular Direction upon its Foot or round Plate at Bottom.

Now the *Grenado* falling in the aboveſaid Direction, the Flints in the Barrel will by the ſuperincumbent Weight of the *Grenado* be violently forced upwards, and conſequently rubbing impetuouſly againſt the rough Inſide of the Barrel, will ſtrike ſuch a Fire, as muſt accend the *Gun-powder* in the *Grenado* through the Holes in the Sides of the Barrel, by which means it will have the ſame Effect as the former.

CHAP. IV.

Of Grenado's *that are ſhot from large* Cannon.

I Shall now deſcribe to you the fourth and laſt Sort of *Grenado's*; (namely) thoſe which are commonly ſhot from great Pieces of Ordnance, to tear down *Ramparts* and make Breaches, almoſt like thoſe made by ordinary *Mines*, though indeed not ſo large or conſiderable. *Pyroboliſts* have from time to time invented infinite Sorts of theſe, but I do not here undertake to treat of them all; I ſhall therefore only dwell upon the moſt ſerviceable of them, and ſuch as you may truſt to, without any Danger of their failing.

SORT I.

Of the numerous Claſs of theſe *Grenado's*, we ſhall give the firſt
Fig. 122. place to that which we have repreſented in *Fig.* 122, which (as may be ſeen) is Spheroidical in its Form and hollow within. Its *Vent* is a Female Screw, contrived exactly to receive a Male Screw, which is beneath a certain Iron Socket: Into this Socket you fix a round Fuze, (or if you will it may be multi-angular) whoſe Sides ſhall be bored all round with a pretty fine red-hot Needle, in an Oblique Manner, or at Acute Angles, all which Borings muſt Center in the Hollow of the Fuze; by which means all their little Orifices will be turned towards the *Grenado*. All theſe, as well as the middle of the Fuze, muſt be filled with *Meal Powder*; and the hollow Screw of the Socket which goes into the *Grenado*, ſhall be filled with one of thoſe *ſlow Compoſitions*, which have been given for the Fuzes of *Grenado's*. Upon this Fuze, and the Socket which receives

ceives it, you muſt fix four Wings, or more if needful, made of thin Copper or Iron Plates, exactly the Length of the Fuze: As for their Breadth, it ſhall be ſo ordered, that the Breadth of any two of them oppoſite to each other being added to the Diameter of the Fuze, they may conſtitute a Right Line which is equal to the leaſt Diameter of the *Grenado*; and conſequently their Breadth muſt be equal to the Diameter of the Fuze, which on the other hand muſt be equal to a $\frac{1}{3}$ of the ſhorteſt Diameter of the *Grenado*.

The Length of the Fuze muſt be ſo nicely proportioned, that being ſcrewed into the *Grenado*, it may be in exact *Æquilibrio* with it. This *Æquilibrium* will be eaſily found, if you recollect what we ſaid of the ſticking of *Rockets*. In ſhort, to conclude with this, you ſhall wrap the Fuze well up in looſe *Quick Match*, and ſalt it over with *Meal Powder*, and then put it into your *Cannon*.

SORT II.

In *Fig.* 123, you have another Sort of *Grenado* of this ſame Species, Fig. 123. which muſt be prepared after the following manner. You ſhall take a common *Grenado*, whoſe Diameter is a little leſs than the Diameter of the *Cannon* you would project it from. It muſt be fixed upon a Wooden Cylinder, whoſe Top is hollowed out in form of a Concave Hemiſphere, ſo as exactly to receive one half of the *Grenado*; its Bottom muſt be flat, but its Head (which we ſhall mention hereafter) ſhall be *Conic*. You ſhall bore an Hole lengthways through the aforeſaid Cylinder, which ſhall have a Communication with the *Vent* of the *Grenado*, and which you ſhall afterwards fill with *Meal Powder*. The Length of this Cylinder ſhall be 2 $\frac{1}{2}$ Diameters of the *Cannon*: Then clap on the aforeſaid *Conic* Head, the Diameter of whoſe Baſe is equal to that of the Cylinder, and which muſt alſo be hollowed out in an Hemiſphere to receive the other half of the *Grenado*. In ſhort, the Cone and Cylinder ſhall be joined in the firmeſt manner with Pitch and Glue: Whatever relates to this, may be eaſily apprehended by the *Figure*.

SORT III.

You have the third Sort of theſe in *Fig.* 124, the Conſtruction of which Fig. 124. is very ſimple: You need only take a Wooden Cylinder as A, equal to the Diameter of the Piece it is to be ſhot from: It is firſt hollowed out beneath in Form of a Concave Hemiſphere, ſo as to be able to receive half of a *Grenado* as B, whoſe Diameter muſt be a little leſs than the *Calibre* of the Piece: The Top of it ſhall be bored with ſeveral Holes, which ſhall all tend towards the *Vent* or Fuze of the *Grenado*; all which ſhall be filled with *Meal Powder* to fire the Fuze. This done, the Cylinder and *Grenado* ſhall be well bound together with ſtrong Iron Wyre. In

ſhort,

ſhort, it ſhall be put into the *Cannon* with the flat End of the Cylinder towards the *Powder*.

SORT IV.

Fig. 125. In *Fig.* 125 you have a fourth Sort of the ſame *Grenado's*, where the Letter D points out the *Grenado* itſelf. C is a Wooden Cylinder of the ſame Dimenſions with the Third above; and has in the ſame manner a Concavity to receive one half of the *Grenado*. E is an Hole bored through the middle of the Cylinder which correſponds with the Fuze of the *Grenado*, and which ſhall be filled with *Meal Powder*. B is a Paper Cartridge fixed to the Wooden Cylinder, and covered at Top with Paper or Wood. This Cartridge holds the Requiſite of *Powder*, which is neceſſary to diſlodge the *Grenado*, as may be ſeen by A in the ſame *Figure*.

This does not differ much from the other ſort we have already ſpoken
Fig. 127. of, and is the ſame which is repreſented in the *Cannon* in *Fig.* 127, except that this laſt does not appear with its Paper Cartridge; which muſt be formed upon a Wooden *Rowler* or *Former* after the ſame manner as the Caſes of *Rockets*. This is filled with *Corn Powder* as in the foregoing Caſe, and as it appears in the *Figure*. Theſe two Sorts require to be charged with great Diligence and Expedition; and particular Care muſt be taken that the *Powder* is not too ſtrong, for fear they ſhould be damaged, from whence unhappy Accidents may enſue.

SORT V.

This Way of ſhooting *Grenado's* from Pieces of *Cannon*, was not only deſigned for projecting one at a time (as may be imagined by what we have hitherto ſaid) but likewiſe for throwing ſeveral ſmall *Hand-Grenado's* at once into the Enemy's Camp, or amongſt the Battalions which are drawn up in Day of Battel. This you may eaſily do, if you ſhut them up in hollow Wooden Boxes or Cartouches, ſuch as you ſee in
Fig. 126. *Fig.* 126. In the firſt place, the Bottom of the Cartouch, A, ſhall be twice as thick as the Sides, and ſhall be re-inforced with an Iron Plate, and wrapped round by a ſtrong Paper Cartridge; or elſe you may tye a little Canvaſs Bag full of *Corn Powder* round it, as you ſee in D. The Fuze C ſhall be either of Wood or Iron, and filled with a *ſlow Compoſition*, by which the *Fire* is conveyed to the *Grenado's* as ſoon as the Box falls amongſt the Enemy.

SORT VI.

We may ſhoot *Grenado's* from *Cannon* without any of the abovementioned Additions to them; but they muſt in this Caſe be thicker at Bottom

tom than in the reſt of their Circumference, as may be ſeen in *Fig.* 128. Fig. 128.
Theſe ſhall have Iron Fuzes which ſhall not in the leaſt degree ſurmount or riſe above the Convexity of the *Grenado*, and the lower Ends of them ſhall be received or let into the Bottom of the *Grenado's*, as may be ſeen by Letter A in the ſame *Figure*. This Fuze (which ſhall be filled with a *ſlow Compoſition*,) muſt be of the ſame Dimenſions as we have ordered for the other Sorts of Fuzes; B ſhews you a Profil of it. The Bottom of this *Grenado* ſhall be turned inwards, or towards the *Powder* in the *Gun*, and conſequently its Fuze muſt be directed outwards towards the Muzzle of it. Though the *Grenado* be fixed in this Poſture, you need not fear its being fired before it gets out of the Piece; for being agitated by the Flaſh of the *Powder*, it muſt in its Excurſion through the Chaſe of the *Gun* be turned and whirled round ſeveral times before it can reach the Muzzle; therefore it will be impoſſible for it to miſs taking Fire from the Flaſh, which wraps itſelf all round it by turns.

SORT VII.

Not long ſince; in the Reign of *Uladiſlaus* IV. King of *Poland* and *Sweden*, His Majeſty's Engineer Major, *Frederick Getkant*, (who for his univerſal Knowledge in the *Sciences* and great Skill in all the Branches of *Mechanics*, deſerves to be called a ſecond *Archimedes* of our Country) contrived a moſt certain and infallible Way, for projecting *Grenado's* from great *Guns*; to which purpoſe he caſt a Piece of *Cannon*, which as to Length is not very different from an old ſort of *Gun* which the *Italians* at this Day call *Canone petriero incamerato:* But it differs greatly from this in its Chamber, which is ſo proportioned as exactly to contain the proper Requiſite of *Powder*. It has moreover two Touch-holes, which terminate in the Vent of the Piece; one of which deſcends obliquely into the Chamber where the *Powder* is, and the other perpendicularly upon the *Grenado*, by which the *Fire* is conveyed to light a kind of *Quick Match* with which the *Grenado* and its Fuze are coated all round; to the end that whilſt the *Powder* is taking *Fire*, the *Grenado* may be in a Readineſs to depart, and only wait for the Motion which is to be given by the Flaſh of the *Gun*. I have taken the Trouble of giving you a Profil of this *Gun* with its *Grenado* lodged in it, as may be ſeen in *Fig.* 129. As to the particular Propor- Fig. 129.
tions of the ſeveral Members of this *Cannon*, I ſhall refer ſpeaking of them to the *Firſt Book* of the *Second Part* of our *Artillery*, where I ſhall deſcant upon them at large, according to the beſt Information I could get from that celebrated Maſter of the *Military Arts* and *Sciences*.

COROLLARY I.

Grenado's of all ſorts may be applied to very various Uſes in the Conduct of War; many of which we ſhall ſpecify in the ſubſequent Chapters. But if you attentively conſider that *Grenado* repreſented under *Number* 118, by the Letter E, you will find it none of the moſt deſpicable. It is firſt ſhut up in two parallelopiped Timbers, which are ſecurely bolted and forelocked together ſo as to keep the *Grenado* fixed and immoveable: It is then fired and thrown down from ſome Eminence, amongſt the Enemy, where it does moſt horrid Execution by the Splinters of the Wood about it, and its own Iron Splinters.

COROLLARY II.

In order to ſhoot *Grenado's* from *Cannon*, the Requiſite of *Powder* ſhall never exceed $\frac{1}{3}$ of the Weight of the *Grenado* and all its Furniture, without which it cannot be conveniently projected.

COROLLARY III.

We have obſerved that *Grenado's* of every ſort of Conſtruction, being fallen upon any Plane, do (by an inconceivable Myſtery of Nature, and ſome ſecret Cauſe not hitherto traced out by the Wit of Man) burſt and fly to pieces in an Angle of 45 Degrees. Whoſoever keeps in mind this Remark, and the wholeſome Advice I now give him, may avoid the Danger of all ſorts of *Grenado's*, and make a Jeſt of them though they be pretty near, if before they burſt he has time to lay himſelf flat on the ſame Plane which they fall upon: This I would have no Body forget, when they happen to be in ſuch a Situation as not only to be oblig'd to ſee them, but alſo to take a Share of them.

COROLLARY IV.

Thoſe who are curious to know the great Things that have been performed by *Grenado's* in the ſeveral Wars, ſince their Invention, may turn over the Commentaries of the Hiſtorians who have in our Age recorded the Remarkable Tranſactions in the *Low-Countries*. Thoſe Gentlemen will tell you (without my giving myſelf the Trouble of doing it) that amongſt innumerable Means for expediting the Sieges and Surrenders of Places, and which contributed the moſt to the Progreſs of the Arms on each ſide, the vaſt Expences of which were almoſt unequal to the entire Revenues of ſeveral *European* Kings and Princes; I ſay, they will tell you that *Grenado's* were always the chief and the firſt Thing they had recourſe to; which by the Induſtry of skilful *Pyrobo-*

liſts

liſts (in which, thank God, the *Low-Countries* are ſo fertile, as to afford to ſpare them to their Neighbours) were ſhowered into beſieged Places, and into the Enemy's Trenches, which ſuch prodigious Devaſtation as cannot be reflected upon without Horrour. How many *Veterans*, and old Citizens have we living at this day, who count themſelves happy, and glory in having been preſent at thoſe deſtructive Scenes? and ſeem to deſpiſe ſuch as have never been, like them, at the Siege of a *Breda*, a *Boiſleduc*, an *Oſtend*, or a *Maeſtricht*, *&c.* which they look back upon, and deſcribe to you with a ſecret Satisfaction of having eſcaped the Danger?

All theſe will concur with me, and confeſs, that the *Grenado's* which were ſent amongſt them from the Enemy's Lines of Approach, not only ſtruck them with Dread, but alſo urged them to a ſpeedier Capitulation than they deſign'd. And how was it poſſible for them to hold out any great length of Time? For according to the Idea I have formed to my ſelf, they could ſee nothing on all Sides but dead Bodies ſtretched out; People buried under Rubbiſh; or elſe frightful Wounds; Arms, Legs and Heads maſhed to pieces; together with the melancholy Ruins of once-magnificent Edifices, promiſcuouſly blended in one common Deſtruction with the obſcureſt private Dwellings; and all owing to *Grenado's*. In ſhort, we may believe that the Calamity was inexpreſſible, and that the Inhabitants could find no Place of Refuge where they could be in Safety.

But to corroborate what I have ſaid, and to ſhew that I do not deſire you to pin your Faith upon my Words only, I ſhall recur to the Teſtimony of two famous Authors who were preſent at the Siege of *Boiſleduc* and *Breda*, and who were careful Obſervers of every remarkable Occurrence that happened. Firſt then, *Daniel Heinſius*, in his Hiſtory of the Seige of *Boiſleduc*, ſpeaks of *Grenado's* in theſe Terms. *The Enemy were not behind-hand with us in any reſpect, but defended themſelves with ſuch Bravery, that we could not gain an Inch of Ground upon them, but by very great* Compulſion, *or by their own Will: During this, nothing was to be ſeen but Balls of Fire* (by which he means *Grenado's*) *which were ſometimes thrown by Hand, and ſometimes ſlung through the Air by Machines, and conveyed Fire and Dread wherever they fell; nothing more cruel or frightful was ever ſeen; and no Word can be more expreſſive of their ſad Effects, than* Death *itſelf: For whenever they fell upon the Ramparts or Houſes, the poor Inhabitants were put into the utmoſt Conſternation; And almoſt as often as our* Engineers *threw any amongſt them, we preſently ſaw Houſehold-goods, Furniture, and Cloaths blown up into the Air; and it is not to be doubted but in a long courſe of Time, and by frequent Repetitions, ſome of them fell into their Arſenals and Magazines. As for thoſe which the Enemy threw amongſt us in our Entrenchments and Works, we had Opportunities of avoiding them.*

Boxhornius

Boxhornius ſays ſomething to this purpoſe concerning *Grenado's*, in his Hiſtory of the Siege of *Breda*; namely: That *three Houſes were demoliſhed by one of thoſe* Fire-Balls *which were called* Bombs. Grenado's *did not fall ſhort of them in Execution, from the Danger of which there was no eſcaping but by a Miracle.*

But I ſhall paſs over a great number of Hiſtorians, whoſe Works are filled with Narratives of this kind; and ſhall only appeal to the Perfidious *Muſcovites* who are ſtill living, and alſo to the multitude of Auxiliaries that joined them, when they inveſted and took the Fortreſs of *Smolensko* in *white Ruſſia*, (which was afterwards retaken from them in the Year 1634) to tell us what they know of the ſtrange Havock made by the *Grenado's*, which the *Lithuanians* threw into their Camp, inceſſantly for three Months together. But if they ſhould be ſilent upon this Matter, our mighty Proweſs has ſtunned them in ſuch a manner (if I may ſo expreſs myſelf) that they will have no more Heart to make head againſt our Victorious Arms for the future, than if they had been thunderſtruck. It will be enough if I inform the World that our *Pyrobolic* Thunder drove them to ſuch Extremities, that thoſe Barbarians could find no Safety even in the Bowels of the Earth; and that though they took Refuge in the moſt profound Caverns, yet our *Grenado's* found them out, and did their buſineſs. In ſhort; perceiving themſelves overwhelmed day after day with freſh Diſaſters, and being quite diſpirited, they were obliged to throw themſelves, and all their Warlike Apparel and Habiliaments, at the Feet of our Invincible and Auguſt King the Great *Uladiſlaus* IV, in the moſt ſuppliant Poſture, begging Life and Liberty, that they might have the Satisfaction of ending their Days in their Native Country, rather than be Food for Wolves and Ravens in a ſtrange Land.

But let us now, on the other hand, confeſs that there is nothing to prevent the Beſieged from demoliſhing the Beſiegers Works, by *Grenado's*,or from putting them into the utmoſt Confuſion and Diſorder; (though indeed not to compare, with the Calamities they cauſe in incloſed Places) to confirm which, I ſhall give you no other Example than the famous Siege of *Oſtend*, which was as Memorable on the ſcore of its Duration, as on account of the many gallant Perſons who there gave the moſt conſpicuous Proofs of the moſt Heroic Bravery. The famous Annaliſt *Paulus Piaſecius*, Biſhop of *Premiſlaw*, ſpeaks thus of it in the year 1601. *They began with throwing a vaſt many* Balls *of Fire, by the Aſſiſtance of Machines; ſo that the Beſieged had no where to ſhelter themſelves; That there was nothing to be ſeen but Artificial Thunder and Lightning, flying backwards and forwards in the Air; and That to his Knowledge there were rather more than* 50000 *thrown into the Town in one Month's time, and* 20000 *from out of it.*

But to what purpoſe ſhould I dwell longer upon this Subject, ſince we have ſtill freſh in our Minds, Inſtances of the famous Sieges carried

on

on lately in *Spain*, *France*, *Italy*, *Germany*, *Poland*, and the *Low-Countries*, (which have always been the grand Theater of War, and principal School of *Mars*;) not to mention particularly the vaſt Numbers of Towns, that have been inveſted over all *Europe*; and have by rueful Experience found (as is alſo allowed by the moſt expert Judges in *Military Affairs)* that *Grenado's* are the Bane of the Beſieged, the Ruin of Cities, and commonly the Death of moſt of the Beſiegers; notwithſtanding that it is certainly eaſier for the latter to eſcape the Danger of them, than the former.

CHAP. V.

Of † Fire-Balls, *which the Latins call* Globi Incendiarii *or* Igniti, *the Italians* Palle di Fuoco, *the Germans* Ernſt *and* Fewer Kugelen, *the French* Boulet a Feu, *the Flemings* Vyer Ballen, *and the Poles* Ogniſte Kule.

SINCE *Fire-Balls* are of a much elder Date than our *Grenado's*, it may be wondered why they did not take place of them, as being the firſt in the natural Order of Things: But the fertile Invention of our Modern *Pyroboliſts* ſuggeſting new Thoughts to them every Day, towards the Improvement of the Old, or Contrivance of New *Machines*, and all New Inventions in every *Art* being commonly eſtabliſhed in Prejudice of the Old, as if for being New, they are of more intrinſick Worth, and more perfect than the former; *Fire-Balls* ſeem to have given up their Place, and to have yielded to *Grenado's*; and are accordingly grown almoſt out of Uſe. However, the frequent Services they have done rendering it indiſputable, that they are in ſome ſort uſeful upon Warlike Occaſions; I ſhall give you the Method of their Conſtruction, and ſhew you their ſeveral Forms and Shapes with us; and thoſe alſo which they had formerly; together with Repreſentations of them drawn in the moſt curious Manner I am able. But before we enter upon a particular Deſcription of them, let us examine a little into their Form, which will facilitate the making of them.

The Form then of *Fire-Balls* may be very various, but the moſt common is that of a Spheroid, or a Sphere: And in Conſideration that they muſt be made of coarſe Cotton Cloth, or any Cloth more ſubſtantial and ſtronger, if any ſuch is to be had; you muſt, to expedite your Work, have *Patterns* (which the *Germans* call *Muſter)* by which to cut out your Cloth, which ſhall be afterwards ſewed up in Oval Bags as a

† Our Carcaſſes are an Improvement upon theſe.

Spheroid, or in Round ones as a Sphere; which must be afterwards filled with combustible Matter, and several *Pyrobolical Compositions.*

The Patterns for Spheroidical Bags may be prepared after several Ways, five of which I shall here communicate to you; and First, Take the Diameter of the *Mortar*, from whence you are to project your *Fire-Ball*, and setting it off upon some Plane, divide it into 4 equal Parts, as
Fig. 130. may be seen in *Fig.* 130. Then fixing one Foot of your Compasses at the Extremity of the Diameter (*viz.*) at B; extend the other to $\frac{3}{4}$ of the said Diameter (*viz.*) to C; and with that opening describe an Arch of a Circle D C E; then shifting your Compasses to the Point C, with the other describe another Arch of a Circle D B E, intersecting the First in the Points D and E; by this means you will have a longish *Figure* comprehended between the two equal Arches D C E B, which will be the Pattern for your *Fire-Ball.* This done, cut out four Pieces of strong Cloth, by the said Pattern, and sew them well together, and you will have a Bag in the perfect Form of a Spheroid, after it is filled with an *Artificial Composition.*

The Second Way of fashioning Patterns for *Fire-Balls* is thus: Divide (as we ordered above) the Diameter of the *Mortar* into 4 equal
Fig. 131. Parts, as may be seen in *Fig.* 131. Then extending the Diameter A B as far as C, in such a Manner that A C may be double of the Diameter A B, you shall divide the Additional Line B C into 4 equal Parts, so that the whole Line A C may be divided into 8 equal Parts: Take then $\frac{5}{8}$ with the Compass, and from the Point A which is one of the Extremities of the Line A C, describe an Arch of a Circle towards C; and then reciprocally from C describe another Arch intersecting the First in the Points E and D; and thus you will have another Pattern which will be a sixth Part of a Spheroidical Bag. Therefore by this Pattern shall you cut out six pieces of Cloth, and sew them strongly together to make your Bag.

Fig. 132. Under Number 132 you have three different Ways of making these Patterns; the First of which (*viz.*) A, is done by assuming the Diameter of the Circle for the *Radius* of the Arcs. The Second (*viz.*) B, by the mutual Intersection of two Circles, whose Diameters are equal to the Diameter of the *Mortar.* In short, the Third is inscribed within the said Circles. These three different Methods give Patterns for three different Spheroidical Bags, when three Pieces only are sewed together.

The common Way of forming Patterns for perfectly Round Bags, is thus: The Diameter of the *Mortar* being bissected into two equal Parts, describe a compleat Circle round it, which you shall quadrisect into four Quadrants, each of which shall be trisected into three equal Arches. This done, produce a Right Line; upon which you shall set off 19 of the
Fig. 133. Subdivisions of the Quadrants, as may be seen in *Fig.* 133 under the Letter A; where A B is the Diameter of the Circle, and B C the Right Line divided into 19 of the abovementioned Parts, each equal to $\frac{1}{3}$ of a

Quadrant

Quadrant of the aforeſaid Circle. Now if you fix one Foot of your Compaſſes at the Extremity B, and extending it to the Eleventh Diviſion deſcribe an Arch of a Circle; and if you reciprocally deſcribe another Arch of a Circle interſecting the Firſt in the Points E and D, you will have a Pattern for Round Bags: Therefore cutting twelve Pieces of new Stuff by this Pattern, and ſewing them together, you will have a Spherical Bag.

In the ſame *Figure* you have another Method of doing this, under the Letter B; which I have taken from Chap. I. of Book III. of *Diegus Ufanus*'s *Artillery*; "Having taken the Diameter of the *Mortar*, "inſcribe it in a Circle, which being divided into Quadrants, by ano- "ther Diameter interſecting the firſt at Right Angles through the Cen- "ter of it; you ſhall from the Extremities of the Chord or Subtenſe of "any one of thoſe Quadrants, deſcribe two Arches interſecting each "other; and from the Point of their Interſection deſcribe a Third Arch; "ſo that they may compoſe an Æquilateral Spherical Triangle. This "done, cut out 8 Pieces of Cloth by this Pattern, and ſew them neat- "ly together, and you will have a Spherical Bag." If you would now ſee the manner of ſewing theſe Bags, caſt your Eye upon *Figures* 134 and 135. Fig. 134 and 135.

Compoſitions *for* Fire-Balls.

Notwithſtanding that all the *Compoſitions* we have already given for *Water-Globes*, might ſerve for *Fire-Balls*; yet becauſe theſe require to have them a little more violent, and are to dart forth a very long Flame, and vomit out a great Quantity of large *Sparks*, to the end that ſuch as would endeavour to ſtifle them may not be able to approach near them; I ſhall touch upon an infallible Way of preparing them, and alſo of trying them after they are made.

COMPOSITION I.

Take of *Meal Powder* 10 ℔; of *Saltpeter* 2 ℔; of *Sulphur* one ℔; and of *Colophone* one ℔.

COMPOSITION II.

Take of *Meal Powder* 6 ℔; of *Saltpeter* 4 ℔; of *Sulphur* 2 ℔; of coarſe Powder of *Glaſs* one ℔; of *Crude Antimony* ℔ ſs; of *Camphire* ℔ ſs; of *Sal Armoniac* one ℔; and of common *Salt* ℥ iiij.

COMPOSITION III.

Take of *Meal Powder* 48 ℔; of *Saltpeter* 32 ℔; of *Sulphur* 16 ℔; of *Colophone* 4 ℔; of Filings of *Iron* or *Hammer-ſlaw* 2 ℔; of the Saw-duſt

duſt of *Fir* or *Pine* boiled in a *Saltpetrous Water* and then dried, 2 ℔; and of *Birch Coal* one ℔.

The *Powder* ſhall be firſt reduced to a very fine Meal for all theſe *Compoſitions*, and paſſed through a very fine Hair Searce: As for the other *Ingredients*, they ſhall be but indifferently pulverized; becauſe if they were to be reduced to a very fine Meal, the *Compoſition* would emit but very ſmall weak Sparks, and thoſe not to any great Length. Or on the contrary, by being in pretty large Lumps, one *Ingredient* could not well incorporate with the reſt, but would all burn independantly of each other, and loſe the *Fire* before it could have time to inflame the Whole: You muſt therefore be very careful in preparing theſe *Compoſitions*, the Goodneſs of which may be tried as follows.

Take a wooden Fuze, or a Paper Caſe, no matter which, of the Height of half a Palm, and the Orifice of it the Breath of half a Finger only: Fill it with your *Compoſition*, and nicely obſerve the following *Prognoſtics*.

If the Flame riſes to the Height of a Palm, that is, to twice the Height of the Fuze which contains it.

If it throws out a good quantity of *Sparks* on all ſides, with a pretty great Noiſe and an acute Crackling; which falling upon the Head of a Drum have Strength enough to break through it, or at leaſt Heat enough to burn it.

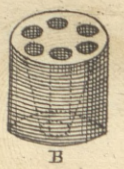
If, in ſhort, it burns during the Time you can rehearſe the *Apoſtles Creed*.

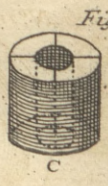
I ſay, if you obſerve all theſe Indications, you may conclude that your *Compoſition* is in very good Temper; therefore you may not only uſe it for your *Fire-Balls*, but alſo for your *Fire-Lances*, *Clubs*, *Garlands*, *Crowns*, *Darts*, *Fire-Hoops*, and the reſt of your *Pyrobolical Machines*, which we ſhall ſpeak ſo amply of in the Sequel. But if you obſerve your *Compoſition* to be either a little too weak, or too ſtrong, you may eaſily make amends for it by adding *Quick* or *Slow Matter* to it. You will not do amiſs, if you ſprinkle your *Compoſition* over with a little of ſome ſort of Oil, that the *Ingredients* may unite the cloſer, and that if your *Ball* happens to fall into Water, or any damp Place, it may be enabled thereby to maintain its Combuſtion with the greater Obſtinacy.

Having thus given you the proper *Compoſitions* for *Fire-Balls*, I can do no leſs than proceed to inſtruct you in the Preparation of the ſeveral Species of them, and ſhew you how you are to charge them.

Of

Fig. N°. 118.





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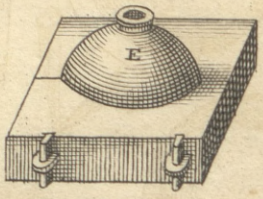


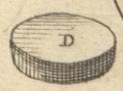
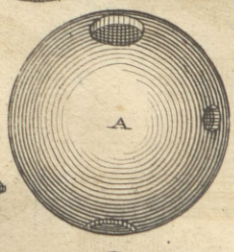
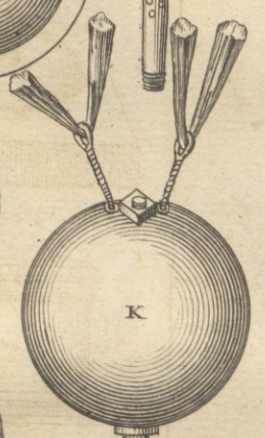
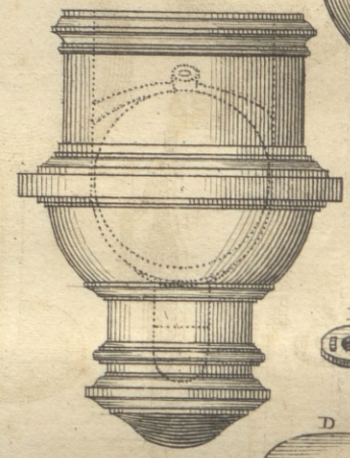


Fig. N°. 120.







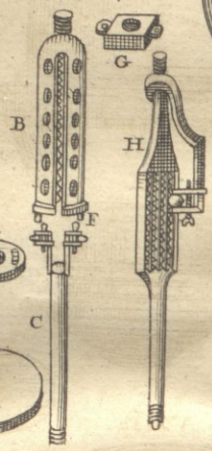
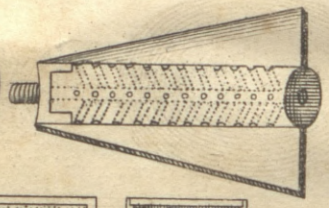


Fig. N°. 121.

Fig. N°. 122.



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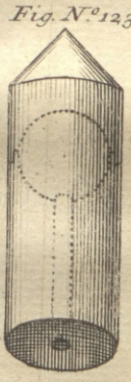

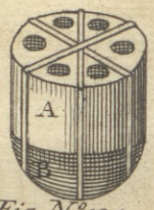

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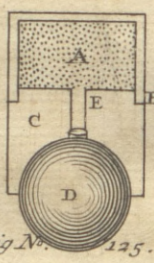

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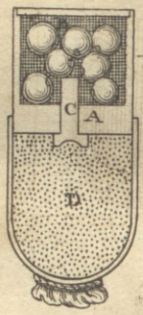

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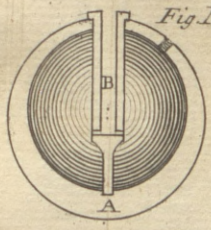
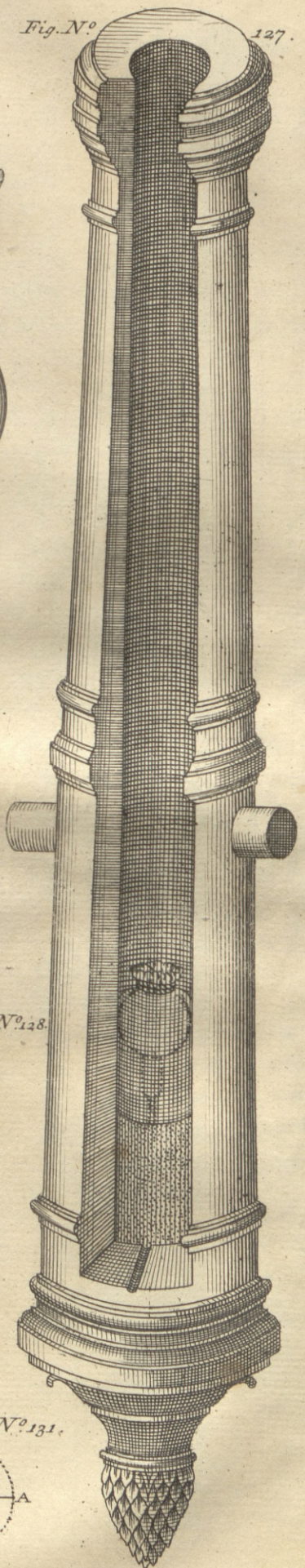


Fig. N°. 128.

Fig. N°. 127.



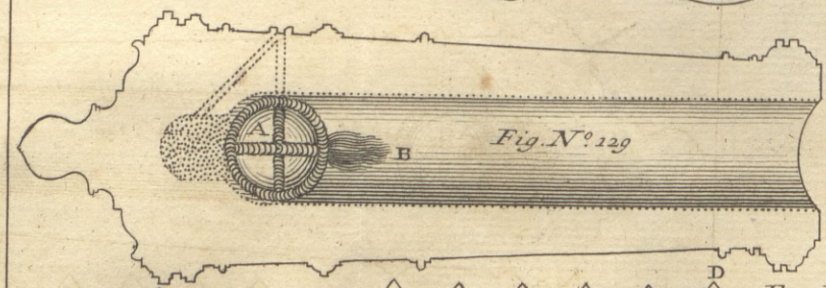


Fig. N°. 129.

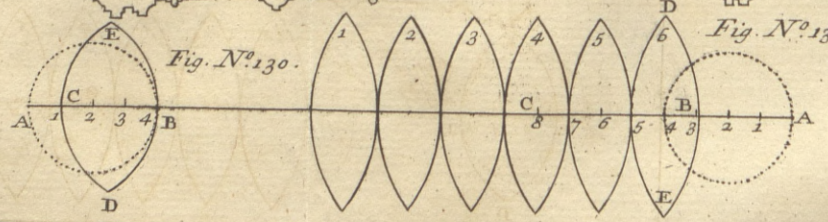


Fig. N°. 130.

Fig. N°. 131.

M

P.F. sculp.

Of FIRE-BALLS.

SORT I.

For this, you ſhall firſt make a longiſh Bag, according to the Order and Method already laid down, and fill it up to the Brim with one of the above *Compoſitions*, preſſing and ſhaking it down as much as poſſible, 'till it is almoſt as hard as a Stone. Then ſtopping the Orifice of it with a Wooden Stopple D; take two Iron Rings, of which that which is to be uppermoſt upon the *Ball* (you have it repreſented in B, *Fig.* 136) Fig. 136. ſhall be $\frac{1}{7}$ of the Diameter of it; and that which is to be beneath ſhall be but $\frac{1}{8}$ only: You have this in Letter A.

But I muſt beg your favourable Acceptance of what I have here taken from *Brechtelius*'s *Pyrotechnics*, relating to this matter. "He "ſays then, that for *Balls* of 100 ℔, the upper Ring ſhall be 3 $\frac{1}{2}$ *Unciæ* "or Inches, and the Lower one 3 *Unciæ* only. For *Balls* of 75 ℔, the "Upper Ring ſhall be 3 *Unciæ*, and the Lower one 2 $\frac{1}{2}$ *Unciæ*. For "*Balls* of 50 ℔, the Upper Ring ſhall be 2 $\frac{1}{2}$ *Unciæ*, but the Lower one "2 *Unciæ* only. For *Balls* of 25 ℔, the Upper Ring ſhall be 1 $\frac{1}{2}$ *Un-* "*cia*, but the Lower one 1 $\frac{1}{4}$ *Uncia* only. For *Balls* which exceed "100 ℔, as for Example, 125, or 150, or more; the Rings ſhall be "increaſed half an *Uncia* for every fifteenth Pound. As for *Balls* be- "tween the Fifteenths, their Rings ſhall always obſerve a *Medium*, be- "tween the next greateſt and the next leaſt; in ſhort, they ſhall be "proportioned as ſhall be judged moſt convenient." As much may be ſaid of their Thickneſs, for according to the Size of your *Balls* muſt you make your Rings more or leſs ſubſtantial, in which you muſt be guided by your Eye. Upon the whole, you muſt take Notice when we mention the Weight of a *Fire-Ball*, that we mean, if the Diameter of the *Mortar* from whence it is to be projected was to be applied to that Side of the *Calibre Scale* which is calculated for *Stone Bullets*, it would point out ſuch a Number of Pounds. This you muſt keep in mind, throughout the Remainder of this *Diſcourſe*.

Suppoſe now you have two Rings of proper Dimenſions, one for the Top and the other for the Bottom of your *Ball*: Take a ſtrong Cord or Line (whoſe Thickneſs muſt not exceed that of the Rings) of the Length of 8 or 9 Yards, more or leſs according to the Size of your *Ball*, and tying one End of it to either of the Rings, and paſſing the other through a Needle (as may be ſeen in the *Figure)* lace your *Ball* tightly round with it, obſerving to do it in ſo neat a manner, that your Lacing may appear like little Ladders of Cord, or (to give you a better Compariſon) like the imaginary Meridians and Parallels drawn upon a *Terreſtrial Globe*; caſt your Eye upon *Figure* 137, where you will ſee it Fig. 137. juſt as I have deſcribed it.

Now to eaſe you of ſome of the Trouble you might be at in Lacing or Cording theſe *Balls*, I have given you the Conſtruction of a Wooden
Fig. 147. Stool in *Fig.* 147, upon which if you fix your *Ball* between the three Iron Spikes which you ſee bent outwards, you may conveniently perform your Work. If you ſhould ſometimes happen, through too much Haſte, or for want of being uſed to this Work, to make any Slips or Miſtakes in your Knots, *&c.* you may undo them with the *Marline-*
Fig. 150. *Spikes*, which you ſee under *Number* 150, diſtinguiſhed by C and D, and E: A and B are two *Copper Needles.*

Having thus laced or corded your *Ball* after the manner we have ordered, you will have nothing to do, but to thruſt *Iron Crackers* into the Body of it, which you may eaſily do by the help of that little Con-
Fig. 149. trivance like a Pole-Ax which you ſee in *Fig.* 149, or ſuch a Borer as
Fig. 146. you ſee in *Fig.* 146. But before I proceed farther, I muſt ſay ſomething concerning the Proportions of theſe *Crackers*, how they are to be fixed, and what Order is to be obſerved in charging them; becauſe we ſhall, for the future, make great and frequent Uſe of them, as very neceſſary Adjuncts to the ſeveral *Balls* we ſhall prepare.

Pyroboliſts uſually make three Sorts of *Copper* or *Iron Crackers*, for their *Fire-Balls*, and each of a different Length; to which they are induced by ſufficient Reaſons and continual Experience, which (according to the common Saying) is the *Mother of all Things.* The firſt and longeſt
Fig. 137. of the three you have in *Fig.* 137, where it is diſtinguiſhed by the Letter A: B is the middling or mean one; and C is the leaſt. We ſhall give Reaſons for this Inequality hereafter; but as to their Length in general, you muſt obſerve the following *Rules.*

You ſhall divide the Diameter of a *Fire-Ball* into 4 equal Parts, one of which will exactly give you the firſt *Cracker* without its Point. The Second ſhall be $\frac{8}{10}$ of the Length of the Firſt, and the Third $\frac{6}{10}$; or if you would rather chooſe to proportion them by the Diameters of *Bullets*, you ſhall proceed as follows.

For *Centenary Fire-Balls*, by which we mean ſuch whoſe Diameters are equal to that of a *Stone Bullet* weighing 100 ℔, the *Crackers* ſhall be made of *Iron* or *Copper Plates* turned into Tubes, which ſhall be ſoldered both without and within if poſſible, and their Orifices ſhall be reinforced with a Ring of the ſame Metals. The Diameter of their Orifices ſhall be equal to that of an *Ounce* of Lead; and their Length ſhall be 6 of the ſame Orifices; I here mean the longeſt *Crackers* only; for the middling ſhall be but 5 $\frac{1}{2}$ Diameters; and the leaſt but 5. For *Fire-Balls* which fall ſhort of this Weight, the Diameters of the *Leaden Bullets* ſhall be inſenſibly diminiſhed, and the Lengths of the *Crackers* ſhall be proportioned, as I ſaid juſt now: You muſt only obſerve here, that the *Leaden Bullets* which are to determine the Diameters and Lengths of the *Crackers* for *Fire-Balls* of 25 ℔, ſhall weigh half an *Ounce:* But for the reſt down from 20 to 15 or 10 ℔ (which

are

are the leaſt that ought to be made) the *Leaden Bullets* ſhall weigh at leaſt two *Drams*: The Lengths of the *Crackers* muſt be as I have ſaid above.

Your *Crackers* being thus ordered, take the little Pole-Ax, or an Iron Spike, and driving it with a Wooden Mallet, which you have in *Figure* 148, into the Spaces between your Cording, thruſt your *Crackers* into Fig. 148. thoſe Holes, in ſuch Order that the longeſt of them may be in the middle part of the *Ball*, and beneath them towards the Bottom you muſt drive in your leſſer; and in ſhort, all round the *Vent* and towards the Top you ſhall drive in your leaſt, ſo that the Ends of them may be turned downwards towards thoſe of the longeſt. However, you muſt be cautious how you put them too near the *Vent*, for fear of their going off too ſoon. You ſhall likewiſe take Care that they be not all in one Poſition, but that they be diverſly diſpoſed, in ſuch manner that their Ends may be turned alternately upwards and downwards to the Right and to the Left, that they may not go off many at a time, but by degrees one after another.

If it happens that your *Fire-Ball* is ſo ſolidly or cloſely filled, as to refuſe Reception to ſo great a Number of *Crackers*, as muſt of neceſſity be thruſt into it, you ſhall (after having driven in the Spike of your little Pole-Ax) compleat the Hole with the *Borer* 146, or ſome Tool like it, with which you may ſcoop out ſo much *Compoſition* as will make room for your *Crackers*.

When theſe *Crackers* are driven into the Body of your *Ball*, you ſhall fill them with good *Powder* to the Height of 3 Diameters of their Orifices, and over that a *Leaden Bullet*, and then a good Wadd of Paper or Tow; and let them be cloſely ſtopped up.

To conclude; the *Vent* of your *Ball* ſhall be made within the Upper Ring, by cutting the Cloth croſswiſe, or like a Star; but you ſhall not have one only; for you ſhall make three others in a Triangular Poſition, and at the diſtance of 3 or 4 Inches from that in the middle, which will be of great Service, and make your *Fire-Ball* as effectual as you could wiſh. Theſe Holes are made to facilitate the Accenſion of the *Compoſition*, and to prevent its Fire from being eaſily ſuffocated by the Enemy with raw Hides, wet Bags or Matreſſes, *&c.* and to aſſiſt it if it ſhould fall into ſoft Earth, or Mudd, Aſhes or Green Turf.

Being thus adjuſted, it is neceſſary to dip it into a certain *Compoſition*, which the *German Pyroboliſts* improperly call *Tauff*, and *Ernſtkugel Tauffen*, which ſignifies to baptize a *Fire-Ball*; this is to be done as follows.

Get firſt an Iron or Wooden Ring equal to the Bore of the *Mortar* you would uſe, the *Figure* of which you have in 145 under Letter A: Fig. 145. In the ſame *Figure* you alſo have a Wooden Board or Iron Plate, bored through with Holes of various Sizes, as in Letter B: Either of theſe Inſtruments are very convenient for meaſuring the Circumference of your *Ball*,

Ball, that you may not inadvertently make it unfit for the *Calibre* of the *Mortar*, in lacing it and in coating it with the following Mixture.

Take then 4 Parts of *Ship Pitch*, 2 Parts of *Colophone*, 1 Part of *Linſeed* or *Turpentine Oil*, and melt and mix them well together in any large Braſs Boiler, or glazed Earthen Pot; and taking this liquid Mixture from the Fire, throw as much *Meal Powder* into it as may be ſufficient to thicken it: Then holding your *Ball* by a String dip it into this Stuff up to the Vent, (which ſhall be previouſly and tightly ſtopped up) and afterwards coat it round with Tow, that its Convexity may be perfectly ſmooth, and the Knots entirely hid.

Whilſt you are dipping it, you ſhall from time to time meaſure it by the above Contrivance, and continue the Immerſion of it 'till it is exactly of the due *Calibre* you want. You have this *Fire-Ball* moſt
Fig. 137. curiouſly repreſented in *Fig.* 137: But we have ſaid enough of it, let us therefore proceed to the reſt.

SORT II.

In the Preparation of this, you muſt firſt have a Bag, (no matter whether it be Spherical or Spheroidical;) in the Bottom of which you ſhall fix 6, 8, or more *Hand-Grenado's* with very ſhort Fuzes, which
Fig. 138. ſhall be turned downwards; (as you may perceive in Letter C *Fig.* 138,) theſe *Grenado's* ſhall be afterwards buried under a proper *Compoſition*, with which the Remainder of your *Fire-Ball* ſhall be quite filled up: You ſhall then have two Iron Baſons like Scales, the Rims of which ſhall be bored through with little Holes. That which you deſign to be uppermoſt, ſhall be open at Top like a Milk-ſtrainer; theſe are diſtinguiſhed by A and B. To the opening of the upper Baſon you ſhall ſolder an Iron Fuze, which muſt be filled with one of the *Compoſitions* we have already given for Fuzes,

This done; clap your Baſons upon the Top and Bottom of your *Ball*, and lace them tightly on, through the aforeſaid Holes in the Rims of them; and dip and coat this *Ball* as you did the Former. You are to add *Iron Crackers* to this, if you will; but you muſt take care that they do not interfere with the *Grenado's*.

SORT III.

Take a round Bag, which being filled with *Compoſition* may form a
Fig. 139. Spherical *Ball*, ſuch as you ſee in *Fig.* 139, 140, and 144, Firſt fill
140, it with *Corn-Powder* to $\frac{1}{4}$ of it's Height, and let it be interſperſed with
and 144. Leaden *Bullets*, bits of Iron, pieces of Flint, and ſuch like Things. The reſt of this *Ball* ſhall be filled quite up with one of the *Compoſitions* already given for *Fire-Balls*, and ſhall be adjuſted on the Outſide like the laſt. You have this, in *Fig.* 140.

In

In ſhort; take a good quantity of *Leaden Bullets* of an *Ounce*, or half an *Ounce* weight, with each a little Iron Needle or Point belonging to it. Arm all the Interſtices of your Lacing with theſe, by driving them into the *Compoſition*; and coat this *Ball* as before, that neither the *Bullets* nor Lacing may appear. The Fuze for this (which you ſee in A) ſhall be filled as uſual. Fig. 139.

SORT IV.

The *Ball* I am now going to preſent you with, is moſt horrible in its Effects; which are the more frightful, becauſe the Treachery of its Conſtruction can be no way ſuſpected; For what can be more ſurpriſing to the Poor People, amidſt whom ſuch a *Ball* is ſent, (who taking it to be one of the ordinary Sort, and accordingly uſe their utmoſt Endeavours to ſtifle it) I ſay, what can be more ſurpriſing to them, than to be on a ſudden moſt cruelly butchered by it: And what is farther extraordinary, it does not perform its Execution all at once, but by a Repetition of 3 or 4 Times, which ſtill makes it the more dreadful. If you would learn the Conſtruction of this, you muſt mind the following Directions.

Take the Diameter of the *Mortar* you intend to uſe, and divide it into 5 Parts in a Stereometrical Proportion. Now though I apprehend I have fully inſtructed you in this Operation in our *Firſt Book*; yet in conſideration of this wonderful Invention, I ſhall ſubjoin the following Method.

Look into the *Table* of *Cube Roots* (which you have in Chap. 1. of Book 1.) for the Number of equal Parts, contained in the Fifth Root, and you will find it to be 171: Divide then the Diameter of your *Mortar* into 171 equal Parts. And ſince in the ſaid *Table* the Firſt Root is compoſed of 100 Parts, you ſhall take $\frac{100}{171}$ of the whole Diameter abovementioned, for the Firſt Portion; $\frac{125}{171}$ for the Second; $\frac{144}{171}$ for the Third, and $\frac{119}{171}$ for the Fourth, which laſt muſt be added to the Fifth, for Reaſons hereafter given; in ſhort, I need not tell you that the Fifth will be 171 Parts.

Theſe Cubical Portions of your Diameter being found, you muſt inſcribe the Firſt, Second, Third, and Fifth, in any Circular Figure, as if they were Original, or Primitive Diameters (as we ſhewed in the ſame Chapter.) Theſe Circumferences will ſerve you for forming Patterns to cut out your *Bags* by.

I have given you a *Fire-Ball* of this Conſtruction in *Fig.* 141, which indeed is Oval, though I muſt own I like the Round beſt. The greateſt *(viz.)* A, which contains 3 ſmaller, has its leaſt Diameter, or (or if you will) its Breadth, equal to the Fifth Portion, or (to ſpeak more intelligibly) equal to the *Calibre* of the *Mortar* it is to be projected from: The like Diameter of B, is the Third Cubical Diviſion; Fig. 141.

and the Diameter of D, is the Firſt or Leaſt. All theſe Diameters are mean Proportionals betwixt two Extremes. The order they obſerve, both as to Capacity and Bulk is thus: If the Firſt or Leaſt *Ball*, D, contains one ℔ of *Compoſition*; the Second C will contain twice as much; and the Third will hold 3 ℔. Thus theſe three, contained by and in each other, need only have 1 ℔ of *Powder* for every one in particular.

In ſhort, the Fourth and Laſt would be ſufficiently capacious to contain 5 ℔ of *Compoſition*; but as the Third is to be included in it, which on the other hand holds the two which are leſs than itſelf, it will require but two Pounds of *Compoſition* to fill it quite up. The Reaſon why this Laſt *Shell* or *Ball* is allowed a greater quantity of *Compoſition* than the three others; is, that the three Leſſer, upon the burſting of the Greater, may ſuddenly take fire one after another; ſo as to give the Enemy no Opportunity of ſuppreſſing or extinguiſhing them, and conſequently they ſhould have but very ſhort Fuzes. For as the whole *Ball* (as compounded of all the reſt) takes up ſome time in its Projection, and requires a few Moments before it breaks after it is fallen, it is proper to allow this Fifth *Shell* or *Bag* that Portion of *Compoſition* and Fuze which would have been taken up by the Fourth.

As to the Conſtruction of theſe *Balls* thus contained in one another, I have told you above, almoſt as much as can be ſaid of it. But I think I had as good repeat it over again.

The Leaſt then ſhall be filled according to the Method preſcribed for the foregoing: *(viz.)* You ſhall fill it to $\frac{2}{3}$ of its Height with the beſt *Corn Powder*, and the remaining Third with one of the above *Compoſitions:* It ſhall then be well corded, and armed with *Leaden Bullets*, and coated with Glue and Tow, inſtead of Pitch. When you put this Firſt into the Second, it muſt have its Orifice exactly anſwering to the Orifice or Vent of the other. The Second ſhall be filled with *Corn Powder* to the Height of the Firſt *Ball*; and the remaining Vacancy with the ſame *Compoſition*. This likewiſe ſhall be firmly laced; and between the Lacing it ſhall be armed with *Iron Crackers* loaded with *Powder* and *Ball*, ſo low as the *Compoſition* reaches; But Care muſt be taken that theſe *Crackers* be not ſo long as to incommode the included *Ball:* Beneath theſe upon the *Corn Powder* you ſhall add *Leaden Bullets*, and under them you ſhall ſtick in little *Iron Spikes* to fill up the Interſtices of the Cording. In ſhort, this *Ball* ſhall be coated with Glue and Tow like the foregoing. The Third ſhall be prepared exactly like theſe two. And finally, the Laſt and Greateſt ſhall be ordered juſt like the three former; but it will bear to have its *Crackers* longer, and in greater Number. It ſhall alſo be armed with *Leaden Balls*, all over that Part of it which contains the *Corn Powder*. In ſhort, you ſhall coat it in the ſame manner as we ordered for the

above

above Species of theſe *Balls*, and be (juſt like them) moſt exactly fitted to the Bore of the *Mortar*.

Obſerve here, that it will be proper for the three *Balls* contained in this laſt to have three *Vents* pretty near to each other, which ſhall be filled with *Meal Powder* to facilitate their Accenſion, and render it a difficult matter to ſuppreſs them.

SORT V.

This *Fire-Ball* is moſt commonly ſhot from *Cannon*, and particularly when you would ſet Fire to the loftieſt Edifices of a Town; or burn any Wooden Houſes, particularly when they are only roofed with Shingle, or thatched with Straw or Reeds; which manner of Building is the moſt common throughout *Poland*, *Lithuania*, *Ruſſia*, *Sweden* and *Muſcovy*. *Cornelius Nepos* tells us, in *Plin. Lib.* XVI. *Cap.* X. that beſides ſeveral Towns in *Spain* and *France*, (witneſs *Cæſar*) even *Rome* itſelf was only covered with Oak Laths for the Space of 470 Years. Add to this the Teſtimony of *Vitruvius*, who confeſſes in *Lib.* II. *Cap.* I. that the Palace, or rather the Cabbin of *Romulus*, was only thatched with Straw, which in Commemoration of that firſt Founder of the *Roman Empire* was always kept whole and entire. This was the Magnificent Pile that *Virgil* ſpeaks of *Æneid.* VIII. where he deſcribes the Work on *Æneas*'s Shield.

In ſummo cuſtos Tarpeiæ Manlius arcis
Stabat pro templo, & Capitolia celſa tenebat;
Romuleoque recens horrebat regia Culmo.

In *Engliſh* thus:

High on a Rock Heroic *Manlius* ſtood;
To guard the Temple and the Temple's God.
Then *Rome* was poor; and there you might behold,
The *Palace* thatch'd with Straw, now roof'd with Gold. *Dryden.*

Ovid alſo gives us to underſtand that the Habitation of this Firſt *Roman* was only thatched with Straw: I leave you to judge what ſort of Dwellings the reſt of the People had.

I ſay then, that it will be very proper to ſhoot *Fire-Balls* from *Cannon* at ſuch kind of Edifices, except they are ſo low, or the *Ramparts* ſo high that they are hid from Sight, for in that Caſe it would be beſt to project them from *Mortars*.

Moſt of the Sieges which have been carried on in our Country, have furniſhed us with Examples, ſufficient to evince the Utility of this Contrivance. Methinks I now ſee *Biall*, a little Town in *Severia*, not indifferently fortified or garriſoned, which was inveſted the ſame Year as the

the *Muſcovites* were forced to deliver up themſelves at *Smolensko*, by that Heroical and Magnanimous Prince *Chriſtopher Radziville* Palatine of *Wilna*, General of the Armies of the Great and Mighty Dutchy of *Lithuania*; who conducting that Siege like a brave Captain, and an excellent Politician as he was, cauſed great Numbers of *Fire-Balls* to be ſhot upon the ſlight Lodgments and Cabbins of the *Muſcovites*, that were only thatched or covered with Shingle, which did them ſuch Miſchief as is not to be conceived, and all they could do, could not preſerve their Town from the Flames. Thus thoſe *Barbarians* found by Experience, that Art and Stratagem are always attended with better Succeſs than blind Rage or inconſiderate Raſhneſs.

I cannot paſs over what *Juſtus Lipſius* relates in his *Poliocreticon*; concerning the prodigious Devaſtation made by *Fire-Balls* in certain Places of *Muſcovy* and *Livonia*, which were beſieged and taken by *Stephen* King of *Poland*; he writes to this Effect: *This great King invented* Fire-Balls *which he threw into the Wooden Retrenchments of the* Muſcovites *and* Livonians: *Upon which thoſe* Barbarians *complained that the Laws of War were violated, and the Honour of Arms polluted, by ſuch unfair and unprecedented Dealings: But our People laughed at them and their Remonſtrances too, and rejoiced in their own Succeſs.*

Theſe *Fire-Balls* are ſometimes uſed in Sea-Fights, to burn the Enemy's Sails and Rigging; in ſhort, to deſtroy their Ships: But theſe ſhould be armed beneath with a bearded Harpoon, to run into the Planks, and to make the Danger of them inevitable: Or that being fired at the Sails the Harpoon may go through them, and keep the *Ball* hanging in them: (But I am inclined to think that the Body of the *Ball* would be driven through the Sails; and that therefore it would be better to ſhoot *Fire-Darts* and *Arrows* at them from a Croſs-Bow) I ſay, the Harpoon piercing through the Canvaſs, and the *Ball* being naturally urged to hang downwards, and the Beard of the Harpoon hindering it from falling down, the Sails cannot avoid taking Fire. All that can be done in ſuch a Dilemma, is at once to clew up the Sails and ſtrike the Yards, in order to extinguiſh the Fire upon the Ship's Deck; which muſt put the Enemy into unſpeakable Confuſion.

Fig. 142. The Faſhion of this *Ball* is clearly expreſſed in *Fig.* 142. The Harpoon I have mentioned is under A. This muſt be ordered by the very ſame Rules as the reſt we have deſcribed; *Crackers* loaded with *Leaden Bullets* would render it dangerous to approach it.

SORT VI.

This laſt Sort of *Fire-Ball* bears ſome reſemblance to that Old *Grenado*, the *Figure* of which you have in Number 115 in its outward Form; but I cannot ſay there is any great Likeneſs between them in their Effects. This *Ball* is grown antiquated and entirely diſuſed, on the

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ſcore of its Form, which will not permit it to move freely through the Air; for we have found by Experience that thoſe *Projectiles* which come the neareſt to a Sphere meet with the leaſt Reſiſtance from that Element; therefore this, approaching nearly to a Cylinder, it muſt be attended with ſome Inconveniences in its Motion: But I ſhall not dwell upon this Point, it being my Deſign to treat of it here-under. You have the Conſtruction of this *Fire-Ball* as follows.

After having taken the Diameter of the *Mortar* you are to uſe (ſee *Figure* 143) conſtitute a Parallelogram whoſe Length is Triple of its Breadth; ſuch as you ſee in the Parallelogram G I K H: Its Breadth G H or I K is equal to C F the Semi-Diameter of the *Mortar*; B C being the Diameter of it. Its Length G I or H K is treble its Breadth, or 1 ½ of the Diameter B C. Then from the Points G and H deſcribe the two Arches H D and G D, mutually interſecting each other in D: But from I and K you ſhall form the *Æquilateral Triangle* I K E. Fig. 143.

By a Pattern of this Shape, you ſhall cut out ſix Pieces of ſtrong Cloth, to make your Bag ſo as to fit the *Calibre* of the *Mortar*, which Pieces ſhall be artfully ſewed together; leaving only an Opening at Top by which to put in your *Compoſition*. It ſhall be then corded as you ſee in Letter A.

Having done all this, you will have a Cylindric *Fire-Ball*, with a Spherical Head and a flat Bottom, which ſhall therefore be put into a flat-bottomed *Mortar*; ſome of which we ſhall give you in the *Second Part* of our *Artillery*, in our Book of *Mortars*.

COROLLARY I.

Of the ſeveral Shapes that may be given to the Pyrotechnical Projectiles; *which of them are the beſt adapted to receive the Impreſſions of a moving Force, and to retain their Motion after it is once communicated.*

THERE are many who are of Opinion, that ſuch *Projectiles* as have a flat Bottom do not require ſo great a Quantity of *Powder*, to carry them to as great or even to a greater Diſtance, than thoſe which are perfectly Spherical: This I ſhall demonſtrate according to their Way of reaſoning, without deviating in the leaſt from their Arguments.

The Modern *Mortars* having their Lengths moſt commonly but 2 or 1 ½ of their Diameters reſpectively, and ſometimes but one only; the *Powder* in their Chambers being inflamed, and accordingly ſtriking againſt the *Ball* or *Bomb* to project it, does not act with its whole Strength

upon it, but the Flaſh endeavours to eſcape through the *Windage* of it, chooſing rather to make its Excurſion through a free Paſſage, than be obliged to remove the ſuperincumbent Weight, and therefore does not ſtrike the Bottom of it with all its Force. The Reaſon of which is, becauſe though the Convexity of an Hemiſphere is always double of its Baſe; (according to the Doctrine of *Archimedes*, *Prop.* XXX of the *Sphere*, and of the *Cylinder Lib.* I.) yet if from the Imaginary Points which the Baſe is compoſed of, you produce right Lines extending to the Convex Surface of the ſaid Hemiſphere, you will find that you cannot aſſign a greater Number of Points to its Convexity than to the Plane or Baſe upon which it reſts. Now the farther any of theſe Perpendiculars are from a certain Line, which you muſt ſuppoſe to extend from the Center of the Baſe to the *Vertex* of the Hemiſphere, the ſhorter will they be; and conſequently, any one of the Imaginary Points on the Convexity of an Hemiſphere being applied to any Plane, will immediately touch it, and be touched by it; but the Points or Extremities of the other Perpendiculars will be exempt from any Contact; becauſe thoſe Perpendiculars are ſhorter than the *Axis*, which is that Perpendicular we juſt now ſuppoſed to be in the Middle: Therefore there can be but one Point of Contact between any Plane, and the Convex Surface of an Hemiſphere. You have this largely and curiouſly handled by *Clavius* in his 15th Prop. and 16th Book III. of *Euclid*: See alſo *Marius Bettinus* Vol. III. Book III. in his *Schol. upon Prop.* I. *of Euclid* Book II and III, and in the following; as alſo in *Theodoſ. Tripol.* Book I. of *Spheres* Prop. III.

If now we ſuppoſe the *Moving* † *Power* of any *Gun-powder*, or the Flaſh of it, to extend itſelf in ſuch a Form as to have a plane Superficies towards the *Projectile*; this Plane will ſtrike and project it in a Point only: Therefore muſt we conclude that the whole impulſive Quality of it is not united, and that it acts upon a *Spherical Projectile* with only an aliquot Part of its whole Force; for a Plane is compoſed of an infinite Number of Points, whoſe Actions and Affections are all independent of each other; wherefore the Affection of the Central Point has nothing to do with that of the others extended all round it, nor has the leaſt Communication with them; (but you muſt here make Allowance for the different degrees of the Natural Solidity of Bodies, which quite alter the Caſe) on the contrary they inſtantly move on, and diſperſing into Rays which embrace the whole Convexity of the ſaid *Projectile*, and acting in an oblique Direction upon the Points of the Convex Surface of it, they cannot be ſaid to drive it out with their compleat Energy; for oblique Rays are ſtronger or weaker the more or leſs they decline from a ſtrait or perpendicular Direction, the Truth of which may be demon-

† Where-ever in the Sequel you meet with the Terms *Moving Power*, *Moving Cauſe*, and ſuch like, you are only to underſtand by them the *Flaſh* of the *Powder* in general; —— Theſe Terms are choſen to avoid *Tautology*.

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ſtrated from *Vitellio*'s *Optics*, &c. Therefore we muſt conclude that the Flaſh of *Gun-powder* does not project a Spherical Body with its united Strength, and that a Sphere is almoſt unfit to receive the Impulſe of it. But it is not thus with a Flat-bottomed *Projectile*; for as all the Perpendiculars which you may ſuppoſe to deſcend from the *Vertex* or Convexity of it, terminate in the Plane of its Baſe, and whoſe Points or Extremities compoſe the Flat Bottom of ſuch a Body, the Plane Surface of the Flaſh muſt impel it with its full and united Power; for every Ray of it muſt of neceſſity ſtrike ſome Point or other of the Bottom of ſuch a *Projectile* in a right Direction, and rebound immediately back again, according to the Nature of the Rays of all *Luminous Bodies*, with whom (as we are taught by *Optics*) the Angle of Reflection is always equal to the Angle of Incidence. Wherefore all the Rays in general being confined and reſiſted by the Body they would project, and having no room to eſcape through the *Windage* of it, they unite their whole Might to remove the Obſtacle which oppoſes their Freedom, and accordingly project it with prodigious Violence: And in this Caſe none of the Flaſh will appear out of the Muzzle, till the *Projectile* is departed from the Piece; nor will it wrap itſelf round the Sides of the projected Body, (as it does with reſpect to *Spheres* or *Spherical Balls*,) and ſoon after quitting it, retire to its Natural State of Reſt; but will adhere to the Bottom of it, drive it forwards, and purſue it a conſiderable Way through the Air, in proportion to the Poſition or Elevation of the Piece, with regard to the Horizon.

Perſons who are uſed to judge of Things by the Lump, may conclude the Arguments I have here produced to be juſt and well-grounded, and may conceive an Opinion that Flat-bottomed *Projectiles* have a great Advantage over the perfectly Spherical Bodies, or ſuch as in any degree incline to that Form.

Therefore having thus demonſtrated, as clearly and ſuccinctly as I could, a Matter which ſeems to have ſome Truth on its Side, and which might be deemed a Fact by ſuch as are dim-ſighted in theſe Affairs: I ſhall do my utmoſt to evince that they are poor, lame, unpoliſhed Arguments, which ſtand in great need of being filed and burniſhed.

In order to which we muſt examine into two Things (*viz.*) *Firſt* the Nature of the Moving or Expulſive Power, the Properties, Qualities, and Manner of Action of the Flaſh of *Gun-powder*, and what Form it aſſumes when it projects any Bodies. *Secondly*, why (contrary to the above Arguments) a Spherical Body is more adapted to receive the Impulſe of the Flaſh of *Gun-powder*, or any other Moving Cauſe, than a Flat-bottomed one; and how it comes to paſs that the nearer a Body approaches to a Spherical Form, it is the more ſuſceptible of Motion.

For the *Firſt* of theſe: The Generation or Production of the Moving Power of *Gun-Powder* can be attributed to no other Cauſe, than to the Fire which inſinuates itſelf into it, and changes the whole Subſtance of

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it (it being naturally very ſubject to Tranſmutation) into another infinitely more ſubtile, and particularly into ſuch as is moſt like itſelf, or which tends the moſt to its Conſervation and Increaſe; for it is laid down as an infallible Maxim, that each *Element* endeavours as much as poſſible to reduce every thing to its own particular Subſtance, from a natural Inclination and Deſire of Infinity and Eternity. This is amply verified in *Fire*, which has a boundleſs Ambition of ſurmounting and poſſeſſing itſelf of every Thing: And being (according to *Scaliger*) as it were the Prince of *Elements*, it greatly extends its Empire by a perpetual Domination, uniting ſome things, and ſeparating others, and exerting its Power over whatever is within the Sphere of its Action, and accumulating whatever can be converted into its own Subſtance. Thus when it ſeizes upon Wood, it knows how to diſtribute the Humidity and Aſhes to the *Earth*, the Exhalations to the *Air*, and never forgets to lay hold on what belongs to itſelf, which it takes Care to keep Poſſeſſion of. The ſame may be ſaid with regard to *Gun-powder*, whoſe Nature being perfectly Igneous, the Fire ſeizes upon the whole Body of it, excepting ſome little Smoke and Soot, generated by the *Coal*, and certain groſs earthy Particles impregnated with the *Sulphur* and *Saltpeter*, which uſually ſtick to the Inſide of the Piece.

Therefore we will call this Virtue, and Moving Force of *Gun-powder*, a certain Natural Property of Fire, compounded of † another which is extremely Subtile of itſelf, (which obliges *Philoſophers* to ſay that it neither burns nor ſhines) and which is Spirable, Violent, Impetuous, Active: Thus this compounded Force diſperſes, thickens, heats, rarifies and burns; is impatient of Oppoſition, incapable of Condenſation, or Contraction. But I ſhould never have done were I to give a particular Detail of all its Attributes!

Since now you have a pretty good Idea of this *Moving Cauſe*, which never had any thing comparable to it; it is neceſſary I ſhould ſhew you its true and natural manner of acting; before I ſpeak of its Form.

But I ſhould think myſelf guilty of a very great Slight to the learned *Scaliger*, if I did not here recur to his Arguments; (though I ſhould not be at a Loſs to illuſtrate it myſelf) for I dare ſay, that no Man ſince *Ariſtotle*, has been ſo diligent an Obſerver of Things, or cultivated Natural Philoſophy ſo effectually as that great and learned Perſon. He ſpeaks thus, in his *Exercitat.* XI. *Not only* Attraction *but* Impulſion *is cauſed by* Rarifaction, *as may be ſeen in Braſs Tubes filled with Saltpetrous Matter; for the Fire in its* Rarifaction *endeavouring to poſſeſs itſelf of the Places neareſt to it, muſt neceſſarily repel and drive forwards; which cannot be properly attributed to* Denſity: *And becauſe* (he ſpeaks to *Cardan*) *this Doctrine of yours has gained ground*

† By this he means the *Flatulent Expanſion* or the *Windy Exhalation* produced by the *Saltpeter*.

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amongſt the generality of People, I ſhall here particularly dwell upon it. You would have us underſtand it thus: (viz.) *the* Powder *being converted into a Flaſh of Fire, cannot be contained in the narrow Space in which it was contained whilſt it was* Powder; *therefore its Parts endeavour to condenſe; but becauſe that is impoſſible, they break out with great violence. But you do not here perceive that the* Rarifaction *is Two-fold. The one being immediately joined to the Expulſion; for it could not fly out unleſs it was dilated: And the other which is the Cauſe of its* Condenſation, *for it would not be condenſed near the* Bullet, *except from its Firſt* Accenſion *it was ſucceſſively rarified. Thus is your Argument falſely grounded, and no ways Metaphyſical, and all from your Ignorance in what concerns the Moving Cauſe: Indeed this* Denſation *is not only ſecondary but accidental alſo; it being a Privation of the natural Property of Fire, which is* Rarifaction. *By what Rule of Nature then can the Privation of the Natural Property of Fire, perform the Effect of it; which is* Impulſion? *Which* Impulſion *is owing to the Endeavour of the Form (or Body) to fill up its Place. Moreover,* Rarifaction *is a Motion, by which the Things rarified extend their Bounds: On the other hand,* Condenſation *is a Motion by which their Bounds are contracted.* Impulſion *is a Promotion of the Extream. Therefore you are miſtaken, to attribute this Motion to* Condenſation.

Here I would willingly check the Courſe of my Pen, were it not for the Nobleneſs of the Subject, which leads us on to a true Knowledge of the admirable Effects, and unſpeakable Strength of *Baliſtæ*, † *Scorpiones*, *Catapultæ*, *Bows*, and ſuch like *Warlike Machines* (which we ſhall hereafter explain, and deſcribe by the moſt Curious *Figures*;) in ſhort, I find ſuch Charms and ſecret Virtues in the Words of this Great Man, that I muſt let him purſue his Subject, whilſt we follow him as cloſe as our Apprehenſions will permit. *You are as much miſtaken when you attribute the Motion of Impulſion in* Baliſtæ *to* Rarifaction. *For it is performed by* Condenſation; *becauſe whenever the Bow of a* Baliſta *unbends it Condenſes. It is thereby made ſhorter, and conſequently muſt be contracted. For which reaſon it breaks ſometimes in the bending; becauſe it is rarified. Now if you aſſert, that this* Rarifaction *is the Cauſe why the Bow unbends and condenſes; you will raiſe two Objections againſt your ſelf. And Firſt: I ſhall deny that it can be any way attributed to it. It is neither Form nor Matter, but an Accident, and a Privation of Denſity, which is owing to the Bow. It is not the Effect: The Effect is* Impulſion. *Is it the Efficient Cauſe? I deny it. No Being can effect what is its contrary, or diametrically oppoſite to its Nature: No* Privation *can perform the Office of its Subject.* Rarifaction *is a Privation of Denſity. The other Objection is: If you will have this* Rarifacti-

† *Scorpiones* were a Sort of Croſs-bows with which the Ancients uſed to ſhoot Poiſoned Arrows &c.

on *to be the Cauſe of the Impulſion, becauſe it is Antecedent to the* Condenſation; *you ſhould allow the ſame thing for* Fire-Arms, *in which the* Rarifaction *is always Antecedent to the* Condenſation. *If a Bow be broken it is becauſe it is too much rarified. Therefore we find that Tough Things cannot be broken, becauſe of their Parts, which will admit of the utmoſt* Extenſion *or* Rarifaction. *Earthen Things break, and will not bend.* Metals *may be rarified, and are therefore flexible. Why do the ſame Bows break if you deprive them of the Spring-pin, the Nut or the Arrow? It is, becauſe whilſt they have any thing that retards their* Contraction, *they are contracted with leſs Violence; but when they are deveſted of all Incumbrances, it is with a ſudden Motion that they unbend, and are therefore Broken. This alſo happens to* Wooden Hoops, *which if they be bent eaſily and gradually, they will follow the Circular Direction you would give them, but if they are ſuddenly bent they break. If it be allowed, that the Concavity of the Bow when bent is condenſed, and on the contrary rarified in unbending; this will agree with us. Perhaps the* Ratio *of this Motion is in proportion to the exterior Circuit of the Bow. But ſome of the more Subtile may deny this Motion to be cauſed by* Impulſion; *but to the preceding Cauſe of* Attraction. *For the String impells the Arrow, becauſe it draws; and it draws becauſe it is drawn. The* Traction *or drawing of the String is the Firſt and Immediate Cauſe; the* Traction *of the Bow is the Second and Laſt. The Cauſe of the* Traction *is the return of the Bow to its Site or Rectitude, which cannot be done without* Condenſation. *It is a Return of the whole, but a* Condenſation *of Parts only. Truly this Motion is different only in Cauſe, and not in Effect. The* Impulſion *is a mere Effect, and the* Condenſation *a mere Cauſe. The* Traction *is the Cauſe of the* Impulſion, *and the Effect of the* Condenſation. *The String of the Bow is broken when it unbends without an Arrow, not for the ſame Reaſon that the Bow breaks (*viz.*) by* Rarifaction, *but by the Strength of the Bow which pulls it violently at each End, in endeavouring to return to its free State: But if the String breaks in bending the Bow, it is broken by* Rarifaction.

Thus far *Scaliger.* I ſhall now reſume the Thread of my Eſſay, in order to which we will firſt conſider the Form and Figure of this Moving Cauſe which is generated by *Gunpowder.*

It cannot be doubted (if you conceive what has been ſaid above) that this Power is no other than *Fire*, or a certain inflamed Air or Vapour; ſince it is evident that *Powder* is almoſt all *Fire in Power* (as *Metaphyſicians* have it) before it is converted into a *Flaſh*, and by the Application of *Fire* to it, it actually turns into a *Flame.* From this it cannot be denied that it aſſumes the Form of *Fire.*

Now we have an infallible Argument to prove, that *Gunpowder* does aſſume the Form of *Fire*, from the nature of *Saltpeter*; which though it be derived from a Saline Humour, yet that Humour is not Aqueous but Aerial, and conſequently hot like Air, and bordering upon *Fire:*

and

and being violently and for ſome time beaten in a *Mortar*, it is greatly rarified and ſubtilized, by being deveſted of all groſs and crude Particles which might be impregnated with it, and therefore ſtill approaches nearer to *Fire*. Now to tell you that it is no way incommoded by being incorporated with *Coal* and *Sulphur*, would be a moſt needleſs Repetition of what I have already demonſtrated.

Again; *Fire*, whether it be Natural, ſuch as it is in its proper Sphere, (which is thought to be neareſt to the Heavens) or whether it be Artificial, which is commonly called *Culinary Fire*; I ſay, whether it be Natural or Artificial, it is a *Body*. I need not go about to prove this Aſſertion, ſince it is allowed to be ſo by the joint Teſtimony of the Learned; and ſince it is a Fact, which is obvious to the Senſes. Being a *Body*, it muſt neceſſary be finite, and circumſcribed within certain Bounds. Thus *Philoſophers* and *Geometricians* tell us, That a Superficies terminates a Body, a Line a Superficies, and a Point a Line: and that *Form* or *Figure* is made up of the different Diſpoſitions of them. Therefore ſome of the Learned have attempted to repreſent the Elements under particular Forms, in imitation of other Natural Bodies: From whence it is that you have the Four Elementary Bodies of *Plato*, to which a Fifth has been added by his Diſciples, as you will find in *Clavius Chap.* 1. *Sphær. Sacrob.* ſpeaks of them to this Effect. Plato *repreſents* Fire *under the Figure of a Pyramid or a* Tetrahedron, *from its aſpiring in a Point, or the Acuteneſs of its Flame. To the* Air *he attributes an* Octahedron: *For as Air is the next in order to Fire, ſo an* Octahedron *bears the greateſt Reſemblance to a* Tetrahedron, *it being compoſed of two Pyramids. To the* Water *he aſcribes an* Icoſihedron, *becauſe of its great Mobility and Fluctuoſity. To the* Earth *he allots an* Hexahedron *or Cube, becauſe of its Immobility; for of all the Regular Bodies, a Cube is the leaſt adapted to Motion. To the* Heavens *a* Dodecahedron; *for even as the whole Circuit of the Heavens contains* 12 *Equal Signs, ſo alſo a* Dodecahedron *is contained under* 12 *Equal Surfaces.*

But in the main you muſt look upon theſe Figures as Emblematical only: For who can believe that Fire artificially condenſed in the Hollow of a *Cannon* or *Mortar* can aſſume the Form of a *Pyramid*? Or who can conceive that the Moving Cauſe, which (as I have often ſaid) is a certain Windy Exhalation or Airy Expanſion, can put on the Figure of an *Octahedron*? This it would be impoſſible for it to do, except when it enjoyed its perfect Liberty to mount upwards. And therefore Fire as well as Water being confined and compreſſed within any Body, puts on the Form of the Cavity wherein it is contained. As for Example, if the Windy Exhalation beforementioned, or rather the Flaſh of *Gunpowder*, was by any Artifice condenſed within a Concave Sphere (ſuch as our *Grenado's*) it would certainly aſſume a Spherical Figure; and ſo likewiſe when it is confined in the Chaſe of a Piece of Ordnance, it muſt take upon it the Form of a Cylinder.

As

As for the Figure of the *Vertex* of the Moving Power, or that End of it which ſtrikes the *Projectile*, it is a difficult matter to aſcertain any thing about it; nor can it be demonſtrated any other way than by Conjecture, or by Compariſons inſtead of Arguments. It is very probable, that it endeavours as much as it can to enjoy its Natural Form; which it may do in Conſideration that the *Projectile* reſiſts it leſs than the Sides and Bottom of the Piece, and is not very capable of hindring it from aſſuming what Figure it will: From whence it is likely it may break out into a Cone or a Pyramid, which are Figures ſeemingly natural to it; add to which, that the main Strength would center in the *Vertex* of ſuch Forms, which being repelled by the *Ball*, would return back again with redoubled Vigour againſt it (by means of its Rarifaction) after the manner of ſome *Purges*. On the other hand, it is not impoſſible but it may take upon it the Shape of an Hemiſphere; which does not appear very unnatural to the Form of Fire and Air when in their proper Spheres, and is the ſtrongeſt of all Figures and Bodies: From whence it is that Porters are naturally led to ſtoop to take up any Burthen, by which means all the Joints of the Body are collected as it were into a ſubſtantial Arch. The Fiction of *Atlas*, whom the Poets feigned to have ſupported the Earth upon his Shoulders, gives us a familiar Idea as to this Doubt.

But to give you the moſt certain and rational Explication of this Matter, and that which is the moſt univerſally received amongſt *Naturaliſts*; we muſt firſt make a Diſtinction between the Situations and Poſitions of the *Projectiles* in our *Mortars*, from whence it will be conſpicuous. You are to underſtand it thus.

All the *Mortars* with which we project *Pyrobolical* Bodies (as we have often ſaid) have certain Chambers, which are to contain the Requiſite of *Powder* neceſſary to perform the Effect required. Suppoſe now that every Corn of *Powder* is at one Inſtant inflamed; and that the *Projectile* cannot be driven out by it, till it is become an Expulſive or Moving Power. Secondly, that your *Projectile* is perfectly Spherical, and that it immediately reſts upon the *Powder*, without the Interpoſition of any Body between them. It is certain, that in this Caſe the Moving Power or Flaſh will not ſtrike upon the whole inferior Hemiſphere of the *Ball*, but on that Part of it only which ſtops up the Orifice of the Chamber, whoſe *Dimitient Line* is exactly $\frac{1}{5}$, or at leaſt an Aliquot Part of the whole Diameter of the Superincumbent *Ball*. Now the *Ball* receives all the Impulſe neceſſary for its Projection, before the Flaſh can make its Excurſion out of the Chamber, and whilſt the whole Energy of the Flaſh is confined in that narrow compaſs; which being once eſcaped from thence, it expands itſelf, and is conſequently greatly weakned.

By this it appears that the firſt Shock is all that is needful, or requiſite for the Projection of the Superincumbent Body. And if the Moving

Force

Force or Flaſh is really collected into an Hemiſpherical or Pyramidical Form, it cannot be doubted (conſidering its Denſity whilſt in the Chamber) that it would impel a round Body moſt powerfully, and hurry it out of the *Mortar*, &c. Nor muſt you imagine, that it acts with leſs Power than if the *Projectile* had been Flat-bottomed, for the Reaſons above given; to which we may add, That the Flaſh being ſtrongeſt, in its Excurſion from the Chamber, it impreſſes its utmoſt Force, and conſequently gives a ſufficient Motion to both a Spherical and Flat-bottomed *Projectile*, by means of that Line only which paſſes through the Center of Gravity, round which all the Parts of the Projected Body are at reſt. Moreover, as a Sphere repreſents a kind of Unity, which may be properly enough ſaid to be but a Point; therefore if it be ſolid and made of any hard Subſtance, ſo that by the Solidity of its Matter and its Form, its Parts cannot be eaſily disjoined, it would be ſufficient if it were ſtruck in a Point only; for from that Point the Blow would be inſtantly communicated to all the reſt. And I am really of Opinion, that this Impreſſion would not have a more powerful Effect, if it had ſtruck the whole Flat Bottom of any *Projectile:* But on the contrary I believe it would be much weaker; for in that Caſe (as I have already ſaid) the *Powder* being extended, its Flaſh would not be collected into a Body of ſufficient or at leaſt ſo great Denſity, and conſequently its Action would be fainter. Thus the Flat Superficies of the Flaſh (if it be a Plane) is no more adapted to impreſs a Force upon a Flat-bottomed *Projectile*, than upon any other.

Moreover, if any Body be placed beneath a *Spherical Projectile*, or one inclining to that Form; or beneath one that is *Flat-bottomed*, which is equal in Weight and alike in Subſtance with the Spherical one: As for Example, let us here ſuppoſe a Tompion to be driven upon the *Powder* in the Chamber in ſuch a manner, that the Flaſh cannot immediately ſtrike either the one or the other of the aforementioned *Projectiles*, and that it muſt give its Blow by means of the Tompion; I ſay, it is moſt certain that whatever Figure the Flaſh aſſumes upon its Accenſion, it will impel and drive out the Tompion with all its Might, and that either of the *Projectiles* muſt equally ſhare in the Impulſe of the Tompion, though their Motion would be unequal, from the Inequality of their *Figure*, as ſhall be obſerved hereafter. What does it ſignify if the Tompion ſtrikes a Flat Bottom in ſeveral Points, or but in one, as it does a Sphere? Since, as we have already ſaid, any Point of a Sphere is as it were the whole Body of it, and *vice verſa*, the whole Body of it as it were a Point: For nothing is ſeperated from it, all its Parts are dependant upon each other, and the Excellence of its Figure admits of no Inequality or Defect in its Surface. As to the Reaſon, why the Flaſh, being eſcaped from the Chamber becomes weak, and unable to impreſs any violent Force upon a *Projectile* of any ſort, I have ſufficiently accounted for it already: But nevertheleſs I will once

more obſerve to you; that the more the Flaſh is confined and reſiſted, the more furious does it become, and ſeems to be ſucceſſively indued with new Degrees of Power, till it has forced its Way to Liberty. And it is for this Reaſon, that beſides the Wooden Tompions which are driven into the Chambers of *Mortars*, they add certain round Boards, equal in Diameter to the Calibre of the *Mortar*, as we have ſaid elſewhere. Therefore we may ſay that theſe round Boards ſupply the want of Flat Bottoms, ſince they prevent the Excurſion of the leaſt Atom of the Moving Power or Flaſh till the *Projectile* is departed. But they are of no farther Uſe after that Moment; for it is impoſſible for them to purſue the projected Body with an equal Pace, whether they remain whole, or whether they be broken by the Violence of the Shock.

Upon the whole, it is an eaſy matter to prove that the Impulſe of the Flaſh upon any Body is Inſtantaneous or Momentary, from the Example of ſuch Things as are thrown by Hand, or ſhot from a Bow or a *Baliſta*; which are never accompanied in their Projection by the *Moving Cauſe*, for it is ſufficient that the degree of Force (let it be what it will) is once impreſſed. There are many of the Learned who maintain, that a Body being once put in Motion, would move on for ever, if its Motion was not deſtroyed by ſome Cauſe; and they hold that this Aſſertion would obtain in a *Vacuum*, or a Space deſtitute of all ſort of Reſiſtance, that might obſtruct and annihilate the Motion given; which *Merſennus* thus accounts for: † *Whatever is produced cannot be deſtroyed, except it be attacked or affected by ſome deſtructive Cauſe; for as no Being has the Power of generating or creating itſelf, ſo no Being can be ſuppoſed to procure its own Deſtruction. There are many great Men who think this to be true, ſince infallible Arguments to prove it may be deduced from what Idea's we have of it: For how can any Body be deprived of the Motion communicated to it, if it meets with no Obſtruction or Cauſe which is deſtructive to it: For it may be ſuppoſed that God would no more deny his Aſſiſtance to* Motion, *which is a* Thing *of real Exiſtence, than to other* Beings; *how then can it be annihilated or ſuppreſſed if it meets with no Impediments?*

Here I ſhould be very willing explain how a Body moves or flies through a Reſiſting *Medium* (ſuch as the Air) if I thought this a proper Place for ſuch an Eſſay; But as I think it is not; I ſhall only remark, that Thoſe are moſt ſtrangely out of the Way, who perplex themſelves in ſuch inextricable Miſtakes, as to imagine, that the Moving Power of *Gunpowder*, purſues the Body for ſome time during its Projection, and that adhering to it, it drives it on with freſh degrees of Velocity; or at leaſt aſſiſts it for ſome time, and prevents it from falling to the Ground ſo ſoon as it otherwiſe would: For what Man living is ſo ignorant, as not to be in ſome ſort acquainted with the Nature of *Fire?* or rather

† Merſen. in Phæno. Balliſt. Prop. XXXVIII.

who

who is he, that has found an Art, or that is able to bind that Element, which is ſo Subtile, Volatile and Light, that Element which is ſo difficult to be handled, to a *Ball* violently hurried through the Air? Who obliges it to adhere to the *Projectile* without daring to forſake it? What magnetical Virtue can an *Iron Bullet* have, that ſhould draw the Flaſh after it? But if I ſhould grant all this, what would it ſignify? How could the Flaſh impreſs new degrees of Force upon the *Ball*, or by what Means could it ſuperadd to the Motion at firſt communicated? Or how could it prevent the Motion from immediately forſaking the projected Body? For being once at full Liberty it becomes ſo ſubtile and rare, that it has none of that Strength it had at the Inſtant of its *Rarifaction*, which Strength conſiſted purely in its *Denſity*, and the compacted Union of its Parts. Thoſe who are obſtinately bigotted to this Opinion are no leſs miſtaken, when they ſay that a *Gun* carries the further the longer it is; becauſe the longer the Flaſh is confined in the Chaſe of the Piece, ſo much the longer does it attend the *Bullet*, and purſue it the cloſer. But we muſt in charity believe that the *poor Men*, who reaſon upon ſuch a wretched foundation, are perfect Strangers to ſome *Rules* in our *Art*, which teach; That if a Piece of *Cannon* is made longer than ordinary, it is not becauſe the Flaſh ſhould thereby be enabled to project the *Bullet* with the greater Violence; but the Length is ſo proportioned, that the Requiſite of *Powder* may be totally inflamed in the Chaſe of the Piece, and that at the Inſtant the *Projectile* is departing from the Muzzle of the *Gun*, the whole Power of the Flaſh may be united, and accordingly project it with its utmoſt Might.

And here I muſt inform you that the longer a *Cannon* is, ſo much greater ought its Requiſite of *Powder* to be; and on the contrary, the ſhorter it is, the leſs *Powder* does it require. For even as too great a quantity of *Powder*, rather hinders than aſſiſts the Projection of the *Bullet*; becauſe it cannot be totally inflamed at the Inſtant the *Ball* departs, and is therefore ſpilt upon the Ground (though ſome *Pyroboliſts* have another way of accounting for this, which I ſhall touch upon hereafter;) ſo on the contrary, too ſmall a Charge is totally accended before the *Bullet* has moved through the Chaſe of the Piece. I ſay then again, that the Flaſh which accompanies a *Bullet* through the Chaſe of a long *Gun* can by no means add to its Velocity, for the longer it remains in the Hollow or Chaſe of it after its Accenſion, and the more Room it has to expand itſelf, the more will it be rarified, and conſequently it muſt be proportionably weaker: So that if there was a *Cannon* of 100 Foot in Length or more, whoſe *Calibre* would only receive a *Bullet* of 1 ℔, which if it was allowed but the uſual Requiſite for ſuch a *Ball*, which is 1 ℔ of *Powder*; I firmly believe that the Flaſh of ſuch a Quantity, in accompanying the *Bullet* through ſo long a Chaſe, would be ſo very much weakened, that it would ſcarce be

able

to drive it of the Piece, much leſs to project it to any great Diſtance. But we ſhall have a more proper Opportunity to ſpeak of the due Lengths of *Cannon*, together with the Weights and Sizes of their *Bullets*, and their Requiſites of *Gun-powder*, in *Book* I. of the *Second Part* of our *Artillery*, where we ſhall treat of *Cannon*.

Let what I have here ſaid ſuffice at once to demonſtrate and perſuade you, that *Pyrotechnic Projectiles* with Flat Bottoms are not near ſo well adapted to conceive a Motion adequate to the Impulſe given, as thoſe which are Spherical or inclining to that Form. Now that what I have ſaid is in every reſpect true, I ſhall appeal to the Demonſtration of *Merſennus* in † *Mechan. Lib.* II. *Par.* III. *Prop.* 6, 7 and 8, where you may conſult him.

From whence it will be evidently demonſtrated, that any *Projectile* inclining to a Spherical Form, makes its Way through the Air with more Eaſe, and penetrates through a *Medium* with leſs Difficulty, than a Cylinder with flat Baſes or Ends. But to this it may be objected, that a Cylinder may not always have one of its Ends foremoſt, nor purſue its Courſe like an Arrow, for it may happen that its Convexity may cleave and rowl in the Air; and that it may alternately cut it with its Convex Surface, and alternately with its flat Ends. But to this I reply in the firſt Place; that it is not impoſſible but that the End of it which is turned Outward in the Piece may be driven on foremoſt. 2. That, though the Cylinder ſhould cleave the Air with its Convex Surface, yet that it would clear its Way with more Points than a Sphere; though they were both to be of equal Weight, and though the Height and Breadth of the Cylinder were to be equal to the Diameter of the Sphere. In this Caſe the Form of the Cylinder would be but little adapted to retain the Motion communicated to it. 3. That if the Cylinder ſhould whirl round in ſuch a manner, that its Convexity and Ends do alternaly preſs forwards through the Air; it is very eaſy to perceive, that there is but little difference between this Motion, and that by which it might move on directly with one of its Ends foremoſt, for its Ends muſt always meet with an equal Reſiſtance as well at one Time as at another. But be this as it will, and whether the Cylinder rowls and whirls about (which is an Action common to all Round Bodies) or not; it is certain that its Motion is in no reſpect like that of a Sphere, and far from being equal to it.

Here by my own good Will could I ſilently paſs over ſeveral admirable Properties which are natural to a Spherical Figure; but I cannot forbear inſerting what *Scaliger*, that Divine Spirit, has obſerved concerning the Sphere, in his *Exercit.* XXX. 1. *With whatever Motion a Globe is turned, we always conceive it to generate a Form like itſelf.*

† The Original has here a long Quotation from *Merſennus*, which being in the main a mere Pedantic Repetition of what has already been ſaid, I thought it would rather perplex the Reader than help him.

2. *Being*

2. *Being whirled round upon a Point, it always fills or takes up the ſame Space, which alſo is common to a* † Cone *from its circular Figure:* Again; *if a Globe changes its place, it deſcribes in the Air a Figure different from itſelf,* (viz.) *a Column; and at the ſame time forms a Line which is not in itſelf, but in Power. Being rowled or ſet upon a Plane it touches it only in one Point, in which wonderful Property it differs from all other Bodies: How then can a Solid Body reſt upon that which has no Exiſtence?* 3. *By one only Turn, it has two contrary Motions (namely) upwards and downwards with reſpect to its Circumference; (I do not here ſpeak of the Heavens, but of any Ball or Wheel;) they are farther contrary, becauſe the Downward Rotation is natural, and the Upward unnatural.* 4. *Notwithſtanding that it is one continued Body, yet ſome of its Parts move with a greater Velocity than others: But you muſt here underſtand Velocity as Twofold; (namely) when Bodies, or Parts of Bodies, go through as much Space in leſs Time, or more in the ſame: Therefore the nearer its Parts are to the Outward Surface, the ſwifter they move; and the nearer they are to the* Axis, *the ſlower.*

In ſhort, the Circle and Sphere ſhall cloſe up this *Corollary*, though they themſelves are endleſs; and they will not only conclude this *Corollary*, but this preſent Year alſo (*viz.*) 1649; the laſt Hours of which our Preſs employs in printing theſe Lines. By God's Leave we ſhall to-morrow not only enter upon a new *Corollary*, but a new Year alſo, a Year of Benediction, the great Year of *Jubilee*, ſo long wiſhed for by the Chriſtian World! The *Almighty*, who has neither Beginning nor End, has this Day compleated the Circle of a wonderful Work, in which every living Soul muſt hold its Courſe without exceeding the circumſcribed Bounds of it. To-morrow we ſhall begin a New Year, which I wiſh may be pregnant of Happineſs, Peace and Joy throughout the whole Face of the Earth: Humbly beſeeching the *ineffable Goodneſs*, that fixing one Foot of the *Compaſſes* of his Love in our Hearts and in our Souls, he would with the other deſcribe a new Circle, which may excite new Degrees of Velocity in us, and haſten us on in an immediate Tendency, towards the endleſs Bliſs of a bleſſed Eternity; to the End, that being far removed from the firſt Point of that Impulſe, which naturally urges us to purſue and covet the Viciſſitudes of Worldly Fortune, we may no longer be expoſed to Danger amidſt the Rocks and Shelves of our Folly: But that on the contrary, continually revolving in an endleſs circular Direction upon the ſmooth Planes of *Fortitude* and *Conſtancy*, we may at length reſume the Place from whence we ſet out (namely) *Heaven*, there to enjoy Eternal Life.

† The *Latin* has it *Pyramis*, and the *French* Tranſlator has rendered it *Pyramide*; but *Scaliger* to be ſure means a *Cone*, which is by *Mathematicians* often defined to be a *Pyramid* of Infinite Sides.

COROLLARY II.

Of ſeveral Sorts of Pyrotechnic Petards *or* Crackers *prepared for various* Military Uſes.

PYROTECHNICIANS have ſeveral other Sorts of *Crackers*, beſides what we deſcribed in treating of *Fire-Balls*. But as in undertaking this Work, I only propoſed to dwell upon the chief *Pyrotechnical Inventions*, and ſuch as are the moſt frequently uſed; therefore rejecting thoſe which are the moſt inconſiderable, and leaſt uſeful, I ſhall refer our *Pyrotechnician* to thoſe *Figures* which he ſees under Number
Fig. 151. 151, diſtinguiſhed by the Letters A, B, C, D, E, F, G, H, I, K, L. The firſt of them (*viz.*) A, is in no reſpect different from that we gave you under *Fig.* 137: This will not only ſerve for *Fire-Balls*, but alſo for *Garlands*, *Crowns*, *Bags*, *Fire-Hoops*, *Lances* and *Darts*; as may alſo the two following diſtinguiſhed by B and C, notwithſtanding that they differ a little from the Firſt. The Proportions of *Crackers* ſhall be determined by the Size of the Body whoſe Uſe you intend them for: But if you would have one fix'd determinate Proportion, you may allow their Orifices the Diameter of a *Leaden Bullet* of one *Ounce*, or two at the moſt; and their Length or Height ſhall be 5 Diameters, without reckoning the Point. This is the moſt juſt and proper Proportion that can be aſcertained for them. As for the Loading of them, pleaſe to look back on what we have already ſaid, to ſave us the Trouble of a tireſome Repetition.

The other *Crackers* which you ſee, are much larger than the abovementioned, and ſerve commonly for *Wooden Balls*, &c. the Conſtruction of which we ſhall give you in the following *Chapters*: The Firſt of theſe (*viz.*) D, is perfectly like the *Recreative Cracker* which we gave you in *Figure* 107 under the Letter A. The Conſtruction of this is very eaſy, and the *Figure* of it is very intelligible. It is uſually charged with *Corn Powder* to $\frac{2}{3}$ of its Height, and the Remainder of it is loaded with *Leaden Bullets*, then ſtopped up with a Wadd of Paper or Tow.

That which you ſee in Letter E is a Triple one, that is, it contains two others leſs than itſelf; though ſimply of itſelf it is perfectly like that which we juſt now deſcribed, (*viz.*) D. This is pierced with five ſmall Holes, for fear it ſhould miſs Fire; four of which are in the Sides, and Diametrically oppoſite to each other, and the Fifth in the Middle of the Bottom of it. As for thoſe diſtinguiſhed by F and G, they are almoſt like thoſe which we formerly repreſented under *Fig.* 106. Theſe

three

three then ſhall be ordered, that the Second may go into the Firſt, and the Third into the Second. The greateſt of them (*viz.*) E, is generally filled with *Corn Powder* to half its Height; upon which you ſhall ſlip down the Middling one, into which you muſt put the Leaſt, filled with *Corn Powder*, and ſome *Leaden Bullets*, after having filled the Second with *Corn Powder* in the ſame manner you did the Firſt; I mean that Vacancy of it which exceeds the Height of the Leaſt. Moreover, the Middling one as well as the Leaſt have Chambers filled with one of the *Slow Compoſitions* I have already given.

The Third *Cracker* which you have in H, repreſents a little Copper or Iron Tube without Bottoms. When you would load this, you muſt divide the whole Height of it into 3 equal Parts, whereof that in the Middle ſhall be filled up with *Corn Powder*, and the other two with *Leaden Balls*. You are to ſeparate them from the *Powder* with Paper Wadds; they ſhall likewiſe be wadded at each End. You ſhall make two Touch-holes, or more if you will, juſt in the Middle of this *Cracker*.

The Fourth of them, (*viz.*) I, needs no Explanation; for it is to be ordered exactly like thoſe whoſe Profils you have in F and G; though it muſt be confeſſed that it differs from them ſo far as to be uſed ſingly, admitting no others into its Capacity, and muſt not on the other hand be lodged in any other when it is to be put in Execution.

In ſhort, the *Crackers* K and L, one of which is in the Shape of a Croſs, and the other of a Carpenter's Square, are to be loaded like the reſt, with one or more *Leaden Balls* according to their Capacities. I ſhall leave the reſt of their Conſtruction to the diligent and ingenious Workman.

COROLLARY III.

Of the ſeveral Sorts of Lacings, Mattings, *and* Ligatures *of* Fire-Balls, *and the* Terms *ſutable to each of them.*

I Find nothing more difficult in the right treating of *Arts* and *Sciences*, than to expreſs myſelf in proper Terms, and to call thoſe Things by proper Appellations which we know nothing of but by continual handling of them; for ſcarce can our Eyes (which are Witneſſes and Examiners of Things) give a faithful Account of them to our Judgment. In truth, Manual Practice is of ſuch great Importance, and bears ſo large a Share in all *Arts*, that if you cannot execute with your Hand what you have conceived in your Mind, you muſt look upon yourſelf as having a Soul without a Body. But as Deſign and Drawing contribute greatly

greatly towards furniſhing us with proper Conceptions of Things, I have repreſented to you the ſeveral Sorts of *Lacings* or *Mattings* of *Balls*, in the moſt familiar manner the Nature of the Work would admit of.

Pyrotechnicians have given Names to the ſeveral Sorts of theſe, according to the Faſhion they are wrought in: The firſt and moſt ſimple of which you have in *Fig.* 136 and 138, which the *Germans* call *Reibbont*. The Second with its various Interweavings, which you have in *Fig.* 137, they call *Pallen-bundt*. That in *Fig.* 142 differs in nothing from this. In ſhort, the ſtrongeſt and moſt artificial of them, which you have in *Fig.* 140 and 144, the Firſt being wrought in Faſhion of a Roſe, and the other of a Snail, they call *Roſen*, and *Schnecken-bunt*. But I refer you to ſkilful *Pyroboliſts* for an ample Information of what farther relates to this matter; as for me, I am in haſte to do other Buſineſs.

CHAP. VI.

Of a Wooden Ball *filled with* Hand-Grenado's, *or a* ‡ Thundering Ball.

JUST as in *Pyrotechnics*, *Hand-Grenado's* are variouſly applied, ſo their Uſes in Warlike Occurrences are very different. You need only have a skilful Artiſt to put them in Execution at proper Times and Places. Now of all the Contrivances for ſhooting ſeveral *Grenado's* at one Projection, I approve of the following the moſt.

Fig. 152. You ſhall have an hollow *Wooden Ball*, whoſe whole Height ſhall be to its Breadth (which muſt be regulated by the *Calibre* of the *Mortar*) in a *Supertripartient* Proportion; that is, as 7 is to 4, though a *Seſquialteral* Proportion might do pretty well. The Bottom of it ſhall be half a Diameter in Thickneſs, to be the better able to withſtand the Shock of the *Flaſh*, and ſhall be rounded without and flat within. The Head or Cover of it muſt be a Concave Hemiſphere, and ſhall be fitted to the Body of the *Ball* by a very nice Joint.

The *Vent* of it ſhall have a Fuze made either of Wood, Iron or Copper, whoſe Height ſhall be half of the whole Cavity of the *Ball*, and its whole Breadth ſhall be of the ſame Dimenſions with the Sides of the *Ball*, which muſt be $\frac{1}{8}$ of the whole Diameter of it. This Fuze muſt be filled with one of the ordinary *Compoſitions* for Fuzes.

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‡ I think this may as well be called a *Thundering Ball*, as a Barrel full of *Grenado's* is called a *Thundering Barrel*.

The whole Body of it ſhall be filled with *Hand-Grenado's*, and the Interſtices between them ſhall be filled up with *Corn Powder*. Above all things you muſt take Care, that all the little Fuzes of the *Grenado's* be turned towards the Bottom of the great one in the Middle of them all, that they may not fail of taking Fire.

The whole being thus ordered, and the Head of the *Ball* firmly glued on, it ſhall be dawbed over with Tar, and coated with a Cloth dipped in the ſame: The *Figure* will give you a clear Idea of every thing relating to this.

CHAP. VII.

Of a Globe *or* Ball *compoſed by ſeveral others.*

THIS *Ball* which I repreſent to you in *Fig.* 153, is nearly both in Form and Effect like the *Fire-Ball* I gave you in *Fig.* 141: Therefore I ſhall refer you to what I ſaid of that, in regulating the Proportions of the Leſſer *Balls* contained in the Greater: But you muſt at the ſame time obſerve the following Particulars. Fig. 153.

1. You may take *Balls* of what Sizes you pleaſe; but the Thickneſs of their Shells ſhall (according to our *Figure)* be $\frac{1}{5}$ of their Diameters, but it may be more or leſs if you pleaſe.

2. The *Balls* ſhall be perfectly round, as well on Account of the Capacity of that *Figure*, as for ſeveral other Reaſons already given.

3. The Hemiſpheres of the three *Balls* B, C, D, ſhall exactly fit each other; but the Fourth, (*viz.*) A, ſhall be only an *Iron Grenado*, whoſe Convexity is armed with *Leaden Bullets*; though by the way, the other three may be made of Iron if you think proper. But let us ſuppoſe them to be of Wood (which will not be very deſpicable:) You ſhall fill them with *Corn Powder*, and ſome of thoſe Iron or Copper *Crackers*, which we deſcribed above in Number 151, under the Letters D, E, H, I, K, L; and then glew the Joints of their Hemiſpheres carefully together: The *Figure* will teach you how to fix them in one another: But I muſt warn you to let the *Grenado* in the leaſt of the three be fixed and immovable, and to let the Head of its Fuze be placed exactly under the Bottom of the Fuze of the *Ball* it is contained in. Each of your Wooden *Balls* ſhall be afterwards re-inforced with pliable Iron Plates of two or three Fingers Breadth, and then well coated round with a Tarred Cloth: Or they may be laced with a Cord like the *Fire-Balls*. If they are all made of Iron, you need only ſolder the Joints of the Hemiſpheres; though I am afraid the Soldering would break by the violent Shock of the Fall: Therefore in ſuch a Caſe it

would be proper to coat them with a *Roſe Matting*, which is the ſtrongeſt of all.

4. The Fuzes for theſe muſt be in Proportion to the Sizes of the *Balls*, and in the ſame manner as we have directed elſewhere, and filled with one of the ordinary *Compoſitions* we have already given for the Fuzes of *Grenado's*.

It were needleſs to amplify upon the wonderful Effects of this compounded *Ball*: But I will venture to ſay, if it be thrown in this Condition into the midſt of the Enemy, ſo as to take them unprepared, it will kill as many Men, and do as much Execution, as the Fire of an hundred Muſqueteers could do upon a whole Battalion.

Obſerve here in the *firſt* Place, that I have repreſented but three *Balls* incloſed in a Greater: But you may have more if you pleaſe, provided they are in due Proportions to that which is to contain them all, whoſe Size muſt be always regulated by the *Calibre* of the *Mortar* they are to be projected from.

Obſerve here in the *ſecond* Place, That if you ſhould not have *Mortars*, theſe *Balls* may be conveniently ſhot from a *Baliſta*; if you think proper to revive the Uſe of that *Machine*: But I apprehend that this Project will excite the Laughter of ſome *poor Hearts*, who cannot ſee beyond the Tip of the Noſe; however, let them laugh or rail on, ſince it is an unalterable Decree that Fools ſhould always riſe up againſt *Truth*, and ſince Ignorance ſo weakens the Faculties, as to render them incapable of bearing the Light of *Reaſon*, who is the Daughter of *Truth*, who alſo is too bright and powerful for their weak Eyes. For my part, I have a due Regard for the Judgment of thoſe great Perſons, who had a perfect Knowledge both of the Ancient and Modern *Arts* of *War*, without undertaking to perſuade thoſe Spirits of Contradiction, who approve of nothing but what is done by themſelves.

Obſerve in the *third* Place, that theſe *Balls* may be projected by one or two Fires, juſt like *Grenado's* or *Fire-Balls*; but they ſhall (if they be made of Wood) be re-inforced with ſuch Iron Baſons as we formerly mentioned, to enable them the better to withſtand the Shock of the Flaſh.

CHAP. VIII.

Of FIRE-RAIN.

PYROBOLISTS, amongſt many other Inventions, have contrived a certain artificial Fire, which they throw at a Diſtance into beſieged Places, (and particularly when the Buildings are covered with Shingle and Laths, or thatched with Straw or Reeds,) which they call

Fire-Rain, and which the *Germans* alſo call *Fewer Regen*. The Preparation or Confection of this is very common, and well known.

Melt 24 ℔ of *Sulphur* in a ſhallow Earthen Pan, over a very clear Fire, free from Flame or Smoke; and as it melts throw into it 16 ℔ of *Saltpeter* and mix them well together with an Iron *Spatula*: As ſoon as they are melted take them off the Fire, and add to them 8 ℔ of *Corn Powder*; mix them all well together, and being cooled pour out this *Compoſition* upon Poliſhed Marble, or Plates of any Metal; and then divide it into Pieces of the bigneſs of a Walnut or Crab; and wrapping them up in Quick Tow, and falting them over with *Meal Powder*, put them into a Wooden Ball, (ſuch as you ſee in *Fig.* 154, which muſt be of the ſame Dimenſitions with the Recreative Aerial *Balls*, under *Fig.* 96, and 97.) and fill up the Interſtices between with good *Corn Powder*, and cover them cloſely and firmly up, and coat the whole with a Tarred Cloth. Fig. 154.

The Priming Chamber and Fuze ſhall be filled with one of thoſe *Compoſitions* which we ordered for the ſame purpoſe with regard to Aerial Recreative *Balls*, or elſe with one of the common Fuze *Compoſitions* for *Grenado's*. In ſhort, as for any thing elſe relating to this *Ball*, I refer you to the Figures beforementioned.

I muſt only warn you of one thing, which is, that the *Mortar* muſt be fixed at ſuch an Elevation that the *Ball* may break in the Air; upon which you will immediately ſee a *Rain* of *Fire*, deſcend, and ſcatter abroad: Thus falling and ſpreading over ſeveral Buildings, it will ſet them on Fire with the ſame Eaſe and Certainty as if the whole *Ball* had fallen upon one in particular.

Beſides the above *Compoſition* (which the *Germans* call *Geſchmoltzenzeug*) you may uſe one of the following, which muſt be prepared in the ſame manner we juſt now directed.

I.

Take of *Sulphur* 3 ℔, of *Saltpeter* 1 ℔, of *Corn Powder* 1 ℔, of Filings of *Iron* or *Hammer-ſlaw* ℔ ſs, and of *Powder* of *Glaſs* ℔ ſs.

II.

Take of *Sulphur* 1 ℔, of *Saltpeter* 1 ℔, and of *Corn Powder* 1 ℔.

Theſe two *Compoſitions* I have borrowed from *Joſeph Furtenbach*, as well as the following; which become very Slimy and Viſcous, when diſſolved by Fire, and that in ſo remarkable a degree that what with their Slowneſs and Tenacity, it is impoſſible to tear them off from any Place after they have once ſtuck to it: Thoſe who are knowing in this *Art* aſſure us (with our Author) that theſe *Compoſitions* will burn through a pretty ſtrong Iron Cuiraſs; and having myſelf experimented them upon a Copper Plate of about the Thickneſs of a *Line*, I can venture to recommend them to you.

III. Take

III.

Take of *Sulphur* ℥j, of *Galbanum* ℥iiij, of *Saltpeter* ℥iiij, and of *Corn Powder* ℥iiij.

IV.

Take of *Sulphur* ℥v, of *Saltpeter* ℥ij, of *Colophone* ℥j, of *Corn Powder* ℥iſs.

In † *La Port's Natural Magic* we find two *Compoſitions* exactly like theſe, which he gives us in the following Terms. *Warlike Machines are ſometimes charged with theſe* Compoſitions; *from whence they ſhoot certain* Balls *of* Fire, *which break*; (Here he agrees very well with us) *they are prepared as follows. This* Powder *is wrapped up in Tow, ſteeped in the Mixture we have already mentioned*; (He juſt before gives us a wonderful *Compoſition* which burns in Water) *they load their Machines with* Balls *ſteeped in this Mixture, and project them at the Enemy. Sometimes inſtead of Oil, and to make them more Fiery, they ſubſtitute Swines Fat, or Gooſe Greaſe, with* Sulphur Vivum, *or* Quick Sulphur *(which the* Greeks *call* ἄπυρον*) Oil of* Sulphur *and* Petrol; Saltpeter *highly refined*; Roſin *of* Turpentine, *of* Tar, Oil *of* Eggs, *and ſometimes to give it a Conſiſtence they add Raſpings of* Lawrel *or* Bay: *Theſe being ſhut up in a Glaſs Veſſel, muſt be buried under a Dunghil or a Dung-heat for two or three Months, renewing it every Ten Days, and ſhaking the* Compoſition. *After which if the* Compoſition *be fired, it burns till it is totally conſumed, and is rather increaſed than repreſſed by the throwing of Water upon it; but may be totally ſuffocated by Dirt, Earth or Duſt &c. If it falls upon Armour, the Men look as if they were on fire, and muſt be either burnt alive, or elſe throw their Armour away.*

We ſhall give you another whoſe Effects are ſtill more extraordinary. Take of Turpentine, *of* Tar, *of* Varniſh, *of* Pitch, *of* Frankincenſe, *and of* Camphire *each one Part*; *of* Sulphur Vivum 1½ *Part, of* Saltpeter *doubly clarified* 2 *Parts, of* Brandy 3 *Parts, with as much Oil of* Petrol *or* Naptha; *to which you may add a little Duſt of* Willow Coal. *Mix theſe well together and make them up in Balls, or fill little Pots with them, and they will burn with inextinguiſhable Rage.* Whoever has the Leiſure and Conveniency of trying theſe *Compoſitions* will find them to anſwer what is ſaid of them.

COROLLARY I.

The *Compoſitions* I have now given you (excepting the two laſt, which I took from *La Porte)* muſt neceſſarily be melted, and well incorporated together, in doing of which it muſt be owned that you will run great danger of being burned; and I remember to have ſeen *Pyroboliſts* who have met with that Misfortune for want of due Care and

† Jo. Bap. De la Port. Lib. II. Cap. X.

Pre-

Precaution. Now to avoid all ſuch ſad Accidents, I ſhall ſubjoin a *Compoſition* which ſtands in no need of being melted at all, and is to the full as effectual as the Former.

Take of *Sulphur* 16 ℔, of *Saltpeter* 8 ℔, of *Crude Antimony* 2 ℔, and of *Corn Powder* 4 ℔; beat, mix and incorporate theſe well together: Then diſſolve common *Glue* in Boiling Water, or (if you will) *Gum Arabic*, or that of the *Plumtree* or *Cherrytree* in Cold or Lukewarm Water, and pour it upon your *Compoſition* in a glazed Earthen Pan; mix the whole well together either with your Hands or a *Spatula*, and make it up in Balls of what Sizes you pleaſe; or to expedite your Work, pour out your *Compoſition* upon an Iron Plate, and cut it out in Lumps, and ſet them to dry in the Sun, or in a Fire-pan, where they may dry by ſlow degrees. In ſhort, when you would uſe them you muſt obſerve the *Rules* already laid down for their Projection.

COROLLARY II.

Hiſtory will bear witneſs, that this *Fire-Rain* which we have ſo amply dwelt upon, derives it Origin from the *Grecian* Fire of the Ancients. Some (as I have already obſerved *Chap.* I. of *Book* II.) attribute the Invention of it to one *Marcus Gracchus*; but *Johannes Zonoras* aſſures us it was invented before the Time of *Conſtantine Pogonatos* Emperor of *Greece*. *Nicetas Choniates* in *Iaacio* ſpeaks thus of it.. *They threw amongſt the poor Inhabitans of the Sea-Coaſts a certain kind of* Grecian Fire *which was held in Pots, and which ſuddenly broke out like Thunder, and ſet Fire to whatever it could reach.*

Others have called this *Grecian Fire* πῦρυγρὸς (which is as much as to ſay) *Wet Fire*, becauſe it was obſerved to burn upon Water, and powerfully to repel all Moiſture. Now to keep my word with you, I ſhall give you the *Confection* of it, juſt as I took it from *Scaliger*: † *Now for* Fires *and* Fiery Compoſitions, *which you undertake to inſtruct us in*; (he ſpeaks to *Cardan*) *but I wonder you have not yet diſcovered how they are called. We have many Writings extant which call them* Grecian Fires; *one or two of which I ſhall willingly ſubjoin, as I took them formerly from ſome* Arabic *Books.* Fire *which deſtroys Iron was invented by the Son of* Amram. *Take of* Tar, *(it is thus I interpret* Zerf) *of* Gum Juniper, *which is alſo called* Samag Agar, *and corruptedly* Sandarax, Oil *of* Turpentine, Oil *of* Bitumen, Oil *of* Sulphur, Oil *of* Nitre, *or* Saltpeter, Oil *of* Eggs, *and of* Oil *of* Lawrel *or* Bay, *each Six Parts.* Powder *of* Dhmeſt *or dry* Bays, *and of* Camphire *macerated in* Brandy; *of each* 14 *Parts. Of* Saltpeter, *to the whole Weight of them all. Put all theſe into a Glaſs Veſſel with a narrow Neck well luted and ſtopped up, then bury it in Horſe-Dung for* 6 *Months. This* Compoſition *ſhall be ſhaken every fourth Day, and then Diſtilled* in ‡ Seraphino. *We have a Deſcription*

† Exercit. XIII. ‡ I take this Term to be of *Hebrew* Extraction, and to ſignifie no more than *diſtilling it over a Fire.*

of another ſort in the Catalan *Tongue. The* Reſiduum *of* Turpentine *after the Oil of it is drawn off*, Oil *of* Turpentine; *of* Tar, *of* Roſin *or* Pitch *of* Cedar, *of* Camphire, *of* Bitumen, *of* Mummy, *of* New Wax, *of* Duck's Greaſe, *of* Pigeon's-Dung, Oil *of* Sulphur Vivum, Oils *of* Juniper, *of* Lawrel, *of* Linſeed, *of* Hempſeed, *of* Petrol, Oil *of* Tyles, *and of* Oil *of the* Yolks *of* Eggs, *each half a Pound. Of* Saltpeter 10 lb; *of* Sal Armoniac 7 *Ounces. Let all theſe ſoak in* Brandy *in ſuch manner as to be covered by it; then buried in Horſe Dung, and renew it every third Day. Then draw off the Spirit* a Seraphino, *which you ſhall thicken with Ox Dung reduced to a very fine Powder: It is this that* Semimaurus *calls* Miraculous; *either becauſe it takes Fire by the Heat of the Sun, or is not to be ſuppreſſed by any means, but by Vinegar, Urine, or Dirt: It burns obſtinately in Water. Theſe* Fires *are thrown in* Pots *at the Enemy, which ſort of* Pots *was called by the* Greeks, ἀϛίαχον.

It appears then that the *Grecian Fires* had the ſame Effect, and were applied to the ſame Uſes as our *Fire-Rain* (namely) to ſet Fire to beſieged Places: But there is one Thing which I ſtumble at; for to tell you the plain Truth, I cannot well conceive how this Fire could be hid and ſtifled (as *Nicetas Choniates* ſays above) ſo as not to perform its Effect, before it reached the Place at which it was thrown. Were the *Veſſels* it was thrown in contrived after ſome ſuch manner as thoſe *Grenado's* which we have called *Blind?* Or were they made of Clay, and ordered like our *Fire-Pots* with lighted Match, *&c?* Or (what I am moſt inclined to believe) did they fire the Matter in theſe *Pots*, before they were projected towards the Places they were deſigned for?

For my part, I cannot perceive what ſhould oblige them to break, if they were not made of Clay or Wood; for it would be impoſſible for this Igneous Stuff to break them by its own Strength, had they been made of Iron or Copper; inaſmuch as its Power extended to a certain degree of Violence, and inaſmuch as it was ſuſceptible of an inextinguiſhable Fire: For notwithſtanding that it had a good Quantity of our *Gun-powder Ingredients* in it, (which I doubt) it would not be ſtrong enough to burſt *Pots* made of any hard Metallic Subſtance, as is done by our *Powder*, to whom alone that Power is granted, and denied to all other Things whether Natural or Artificial. There have been thoſe who have related Wonders concerning the ſtrange Effects of *Aurum Fulminans*, by which it ſeems even to ſurpaſs *Gun-powder* (to which I have partly conſented:) But as its Operations are directly oppoſite to thoſe of *Powder*, and ſince it is of no Uſe in our *Fire-Works*, we will not give it a Place amongſt theſe combuſtible Things. But to return to our *Grecian Fire*; we have a familiar Inſtance of the natural Imbecility of it, in our *Pyrotechnic Compoſitions* which we call *Slow*, which (beſides that they are compounded of ſome of the ſame *Ingredients* as the ſaid *Fire*,) are made up not only of *Saltpeter* but alſo of *Meal Powder*, and even a Portion of the ſame in Corns; yet if you fill a Fuze or a Shell with

them, they will burn without doing the leaſt Damage to the Veſſels which contain them, except they are very thin and ſlight, or are not well re-inforced with a proper Coating, or except the Fire is too much confined. Moreover, we make *Slow Compoſition* of *Meal Powder* only, which if it be put into Wooden or Paper Caſes, and fired, it will not in the leaſt hurt them: How little then would it be able to burſt Veſſels made of Iron or Braſs, like our *Grenado's*, which are with difficulty affected even by our *Corn Powder?* For I muſt remind you, that whenever the *Corns* of our *Powder* are disfigured, they are diveſted of their Strength, and are ſo far from being able to break Veſſels made of Metal, that they would not ſplit them if made of Wood, provided they are of moderate Thickneſs, well coated with tarred Cloth, and re-inforced with ſtrong Cord or Marline.

We will conclude then, that the Veſſels which held the *Grecian Fire* were made of ſome Wood or Metal, and that they were open, and not covered up like our *Fire-Pots*, which are at preſent in ſuch great Requeſt with us. Say we farther; that the Matter contained in them was covered by ſome very *Slow Compoſition*, to prevent the Fire from ſeizing upon it, before it had arrived at its intended Length. Or elſe we muſt believe, that it was covered by ſome ſort of Spunge, or that it had lighted Match in the Mouth of the Veſſel, which perhaps was covered with a Cloth, or ſome looſe Wooden Lid; and thus the Matter being accended, flew out impetuouſly, and conſequently burned and deſtroyed every thing within its reach.

However I do not deny, but thoſe who uſed this *Compoſition* might be ingenious enough, to contrive that theſe Pots of Earth or Wood ſhould break in the *Air*, from whence the Matter they contained, falling and ſcattering abroad unlighted; it would be impoſſible to ſee it fall, or to diſtinguiſh it after it was fallen, and accordingly at firſt it did no Damage: But being ſoon afterwards kindled by the Heat of the Sun (which is not impoſſible, according to *Scaliger)* or accended by the Wind, or Rain, or Dew (I ſhall give you ſome ſuch *Compoſitions* hereafter) it muſt conſequently take Fire, and burn whatever it fell upon. Now perceiving that *Compoſitions* of this Nature made into Lumps or Cubes, and ſhut up in a Wooden Ball, may be ſcattered abroad in the Air by *Gunpowder*, and fall down lighted or unlighted into beſieged Places; I thought it would not be amiſs to inſert the following *Compoſitions*, and to inſtruct you in the Confection of them, according to the Directions left us by Authors; notwithſtanding that what I have already given you from *Scaliger* is none of the moſt unfit for our Purpoſe.

La Porte ſaith: † *There is a* Compoſition *which catches Fire by the Heat of the Sun; particularly in thoſe Regions where the Sun is very powerful; which muſt be compounded of very* Igneous Ingredients; *for Ex-*

† Joh. Bap. de la Port. Lib. II. Cap. X.

ample:

ample: Take of Camphire, *of* Sulphur Vivum, *of* Turpentine, *of* Gum Juniper, *and* Oil *of the* Yolks *of* Eggs; *together with* Tar; Powder *of* Colophone, *of* Saltpeter, *and of* Brandy *to the double of them all, and a little* Arsenic *with as much* Tartar: *All these being pounded and well mixed, put them into a Glass Vessel, and bury it for two Months under a Horse Dung-hill, which must be frequently renewed, and the* Composition *as often shaken: Then draw off the Liquid Part of it in the same Vessel it had been buried in, (as we shall shew hereafter) which Liquid shall be thickned with some of our* Powder (he means a certain *Powder* which he had just before mentioned for *Water-Balls*) *or with Pigeon's Dung finely pulverized, so as to give it a pretty dense Consistence.* (This may be made up in little Lumps.) *With this dawb over all the Wooden Work or combustible part of a House upon some hot Summer's Day. All this is ascribed to* Marcus Gracchus. *Pigeon's Dung is of a very fiery Nature:* (I must observe here that the Dung of Geese, Ducks, Hens, *&c.* being well dried, is also very combustible; but he goes on) Galen *relates, that in* Mysia, *which is a part of* Asia, *there was a House burnt by the following Accident. A Parcel of Pigeon's Dung being thrown under a Wooden Window, which had been lately done over with Rosin, so as to touch it: This Dung being rotted, and much heated by the Sun upon a very warm Day, and emitting very hot Vapours, the Window took Fire, which soon after got hold on the Roof, and in a little time spread all over the House.*

The same Author saith in the same Place: *That if you would make a Fire which shall be extinguished by Oil, and accended by Water, you must confect it of such Things as burn the most readily in Water, or that burn in it of their own Accord, such as* Camphire *and* Quick Lime: *From whence it is that if you make a* Composition *of* Wax, Petrol, *and* Sulphur, *it will be extinguished by Oil or Dirt; but if you throw Water upon it, it will revive and burn with renewed Vigour. Of this* Composition *they make* Torches *which burn in great Rains, or in crossing of Rivers.* Livy *tells us, that certain old Women, at a time when they were celebrating their Games, took* Torches *made of this, and swam over the* Tyber *with them, by way of Miracle.*

Cardan saith: † *That Water accends violent Fires; because the Moisture it exhales is rendered more Fat and Greasy, and is not wasted or destroyed by circumfused Smoke, but is totally devoured by the Fire; from whence being purified, and united by the Cold, it springs up with the greater Alacrity; and therefore those* Fires *which are excited or accended by Water, shall be compounded of* Ship *or* Greek Pitch, *of* Sulphur, *of the* Lees *of* Wine, *commonly called* Tartar, Sarcocolla, Saltpeter *and* Petrol: (*all this is attributed to* Marcus Gracchus.) *To these must be added a double Portion of* Quick Lime, *and the* Yolks *of* Eggs; *these must be mixed well together, and buried in Horse-Dung.*

† Card. Subt.

The

The ſame Author in the ſame Place: *Take* Oil *of* Petrol, Oil *of* Juniper *and* Saltpeter, *of each equal Parts*; *of* black Pitch, *of the* Greaſe *of* Geeſe *and* Ducks, *of* Pigeon's Dung, *of* Liquid Varniſh, *the ſame Parts of each*; *of* Aſphaltites *or* Bitumen *five Parts*; *put them all into* Brandy, *and bury them in Horſe-Dung.*

The ſame Author in the ſame Place again: *Take of* Liquid Varniſh, *of* Oil *of* Sulphur *and* Juniper, Oil *of* Linſeed *and* Petrol, *and of* Turpentine, *equal Parts of each*; *of* Brandy 3 ½ *Parts: Then of* Saltpeter *and dry* Lawrel Wood *both well powdered, enough to thicken the Whole, and give it the Conſiſtence of a Lute. Put all theſe into a Glaſs Veſſel, and bury them three Months in Horſe-Dung. If the* Balls *made of this ſtick to any Wood, they will be accended by Rain: However, they will not always anſwer to this Effect*; *but being once enkindled, they never fail to burn in ſuch a manner, that it will be to no purpoſe to endeavour at extinguiſhing them by Water.*

Scaliger ſaith: † *I afterwards met with a little Book which teaches how to make ſeveral Sorts of* Salt, *and* Alum, *and to confect a* Fire *which will be accended by Spittle, and was frequently uſed by Thieves and Robbers:* (*Pyroboliſts* may uſe this in the honourable Robberies of War.) *Take* Oil *of* Sulphur, *of* Turpentine, *of* Cedar, *and* Tar, *of each* 14 *Ounces*; *of* Saltpeter 16 *Ounces*; Sal Armoniac, Vitriol, calcined Tartar, *of each* 8 *Ounces*; calcined Loadſtone, Quick Lime *of* River Pebbles, *of each half an Ounce*; Tallow *and* Duck's Greaſe, *of each* 6 *Ounces. Being all covered with* Brandy, *bury them in Horſe-Dung for three Months, (in the Margin it was written in the* ‡ Dung of a Mare with Foal.) *It muſt be ſhaken every fourth Day*; *then heated over a Fire that the Liquid Part of it may evaporate, and the* Fæces *or hard Part remain behind: Then break the Veſſel to get at it, and pulverize it. If the Powder of this be ſcattered over Water it burns vehemently. This I have inſerted to evince how great an Enemy I am to Juglers and Mountebanks*; *upon which Account alſo I ſhall add a Fable framed by* Ct. Cnidius: *This worthy Gentleman pretended that he knew how to extract an* Oil, *from a certain River* Worm *of* India, *with which the Kings of* Perſia *uſed to burn the Enemy's Towns, by only dawbing or ſprinkling them over it.*

Ælian. Lib. V. *Hiſt. Arim. Cap.* V. *& Ammianus Lib.* XXIII. relate; That the Kings of *Perſia* uſed a certain *Oil* with which they ſet Fire to Towns, and burned down their Gates, and that it was impoſſible to ſuppreſs the Flame of it even with Water, it being naturally able to withſtand the Effects of that *Liquid Element.* This *Oil* was made of *Petrol* or *Naptha.* But if what *Ct. Cnidius* ſays of this *Perſian Oil* appears fabulous to *Scaliger*, what would he have ſaid of a certain Water mentioned by *Leonard Fronsberger*, which has ſuch an extraordinary

† Scal. Ex. XIII. ‡ The Original has it: *Cooperta omnia ſepeliantur in equi ventre per menſes tres, in margine ſcriptum fuit, in equa fœta ventre.*

Property, that if a Piece of Cannon be charged with it, it will project a Bullet to the Diſtance of 3000 Paces? He orders it to be compounded of 6 Parts of a *Saltpetrous Lixivium*, 2 Parts of *Oil* of *Sulphur*, 3 Parts of *Water* of *Sal Armoniac*, and 2 Parts of *Oleum* or *Balſamum Benedictum*. For my part, I can ſay nothing of this till I have made the Experiment. But upon the Whole, I do not apprehend that *Scaliger* had any great reaſon either to ſay or believe, that what he ſpeaks of above is a Forgery and a Jugling Trick; for I am perfectly of Opinion, that it is not impoſſible to be true; and you may venture to think it a Fact, ſince I myſelf have found by Experience, that it is an eaſy matter to make *Compoſitions*, which will immediately catch Fire by ſprinkling them over with Water, and break ſoon afterwards into a Flame, without the leaſt Application of any Fire whatſoever to them. Now this Accenſion is purely owing to *Quick Lime*, to which you add certain Portions of hot and fiery Subſtances: I ſhall give you two of theſe *Compoſitions* of my own Invention, and which I have tried myſelf.

I.

Take of *Saltpeter* 10 ℔; of *Sulphur Vivum* 6 ℔; and of *Quick Lime* 20 ℔.

II.

Take 6 ℔ of *Saltpeter*; 4 ℔ of *Sulphur*; ℔ ſs of *Frankincenſe*; ℔ ſs of *Linſeed Oil*; ℥ iiij of *Oil* of *Petrol*; 8 ℔ of *Gun-powder*; 12 ℔ of *Quick Lime*; and one ℔ of the *Juice* of *Onions*.

The two following are from *Frønsberger*.

I.

Take equal Portions of *Copperas-Water*, *Sulphur*, and *Oil* of the *Yolks* of *Eggs*, and putting them into a glazed Earthen Pan, fry them over a good Coal Fire, till they have acquired the Conſiſtence of a Conſerve; then add to them a fourth Part of *Wax*, and incorporate them well together: Preſerve this *Compoſition* in an oiled Bladder, and ſtop it up cloſely with Wax ſo as no Air may have acceſs to it. Our Author aſſures us, that this Mixture being expoſed to the Wind in any open Place, it will take Fire, and that being wetted by Rain, it flames out, and that the Fire of it ſpoils, deſtroys and devours every thing within its Reach.

II.

Take *Quick Lime* of *Venice*, *Gum Arabic*, *Sulphur*, and *Linſeed Oil*, equal Parts of each; incorporate them well together; and when you have a Mind to make Tryal of the Effects of this Mixture, ſprinkle it over with a little Water, and it will be lighted, and dart out Flames on all Sides.

To theſe two I ſhall add a Third and Fourth, taken from *Jerome Ruſſel* an *Italian*: The firſt of which is the *Compoſition* of a Stone, which being put into Water, or only moiſtened with Spittle immediately takes Fire. Take then *Quick Lime*, *Tutia* unprepared, *Saltpeter* ſe-

veral

veral times clarified (according to the laſt Method I gave you) and *Loadſtone*, of each 1 Part; *Sulphur Vivum* and *Camphire*, of each 2 Parts: Put them into a narrow Earthen Pot, and this Pot into a large Crucible, and cover it with another of equal ſize; tye them faſt together with Iron Wire, and lute the Junctures well up, that it may be impoſſible for any Air to inſinuate itſelf; in ſhort the Lute being thoroughly dry, you ſhall ſet theſe Crucibles into a Lime or a Brick *Kiln*, and as ſoon as the Lime or Brick is ſufficiently burned, take your Crucibles out and break them, and you will have an hard Body like a Stone.

The other of this Author's Invention is thus; Take of *Oleum Benedictum* 1 ℔, of *Linſeed Oil* 3 ℔, of *Oil* of *Eggs* 1 ℔, of *Quick Lime* 8 ℔: Mix and incorporate all theſe together according to Art. He aſſures that if any Thing whatſoever is ſmeared over with this it muſt infallibly be burned, nor can the *Fire* of it be ſuffocated by any means, particularly if never ſo little Rain falls upon it. There are thoſe who attribute the Invention of this to *Alexander the Great*.

Thoſe who would be farther informed of this Matter, may conſult theſe Authors, who will give them all the Satisfaction they can wiſh. I ſhall only ſay that theſe *Compoſitions*, when well prepared and proved, may be applied to ſeveral Uſes in *Pyrotechnics*; for beſides the ſeveral purpoſes for which they were invented, they may ſerve to burn any thing in Water. Thus if you would burn a *Wooden Bridge*, you may at Low Water, ſend little Boats or Wooden Cheſts down the Stream towards it, well bound with Iron, and filled with *Hand Grenado's*, the Interſtices between which may be filled up with one of theſe *Compoſitions*; taking care that theſe little Veſſels or Cheſts be well ſhut up, and payed with a good Coat of Pitch, leaving only a very little Hole, through which the Water may inſenſibly drop amongſt the ſaid Mixture; and taking care to order the whole of it ſo that it be exactly of the ſame Specific Gravity with Water, for Reaſons formerly given, that it may with the more eaſe be carried by the Stream to the *Bridge* you have a Deſign upon; which your Cheſts may catch hold on by Hooks or Graples artfully contrived for that Purpoſe, till the *Grenado's* take Fire by means of the *Compoſition* by which they are encompaſſed round, and by their uſual Effects ruin and demoliſh the *Bridge* they ſtick at.

If your Curioſity inclines you to ſee theſe little Veſſels ſwimming under the Surface of Water, you may find them in *Merſennus* in his *Coroll.* II. *Prop.* 49 of his *Hydraulics*, and in *Book* II. of his *Art of Navigation*; as alſo in *Harmon Prop.* 6. *Advert.* V. From whence the Ingenious *Pyroboliſt* may furniſh himſelf with a great many fine Hints; and put them in practice in his Artificial Fireworks. For my part, I ſhall content myſelf with having pointed out to you the Places where you may find them.

CHAP.

CHAP. IX.

Of LIGHT BALLS.

IN the *First Part* of this *Book*, in *Chap.* III. and *Coroll.* I. we ſhewed you how to prepare *Recreative Light Balls:* I am now going to give you the Military Sorts of them, which are more dangerous and better adapted to do Execution in the the Occurrences of War. They are thus.

SORT I.

Take equal Quantities of *Sulphur*, *Pitch*, *Roſin* and *Turpentine*, and melt them in a glazed Earthen, or Braſs Pot: Then take a *Ball* either of Stone or Iron, whoſe Diameter is ſomewhat leſs than the *Calibre* of the *Mortar* or the *Cannon* it is to be ſhot from, and dip it all over in this Melted Stuff; which done, take it out and rowl it gently in *Corn Powder*. Then wrap it up in a Cotton Cloth, and immerge it again into your *Compoſition*, and taking it out again rowl it a ſecond time in *Corn Powder*, and wrap it up again in a Cotton Cloth; in ſhort, repeat this Operation till your *Ball* is of due Size: But you muſt take care that the Laſt Cruſt or Coat of your *Ball* be of *Corn Powder*. Being thus ordered fix it in your *Mortar* or *Cannon* naked as it is, without any farther Cove-
Fig. 155. ring, and project it where you pleaſe. See *Fig.* 155, diſtinguiſhed by Letters A and B.

SORT II.

Take of clarified *Saltpeter* 1 Part, of *Sulphur* 1 Part, of *Orpiment* 1 Part, and of *Pitch* 1 Part, of *Colophone* ½ Part, of *Varniſh in Grains* or *Gum Juniper* 1 Part, and of *Frankincenſe* 1 Part. Reduce theſe Ingredients to a fine Meal, and incorporate them well together. Then take of *Turpentine* 1 Part, of *Mutton Suet* 1 Part, and of *Oil* of *Petrol* ½ Part: Melt theſe in an Earthen or Copper Pan over a ſlow Fire, and as ſoon as they are melted, throw the above pulverized *Compoſition* into them, and mix them all together. In ſhort, throw in a good quantity of *Flax*, *Hemp*, or *Cotton* amongſt them, to give the whole ſuch a Stiffneſs, as to bear making up in *Balls*; after which make it up in *Balls* accordingly, of what Sizes you pleaſe. Theſe may be thrown amongſt the Enemy when they are in the *Ditch*, or at the Foot of a *Rampart*, or preparing for an Aſſault; they will alſo ſerve to annoy thoſe who are at work upon the *Galleries*, or who approach you by Sap to lodge themſelves in the *Mines*: By their Brightneſs they will

alſo ſhew you whatever is doing without your Walls; in ſhort, theſe Nocturnal Lights will diſcover to you all the Enemy's Contrivances and Stratagems, to compaſs the Ruin of your Fellow-citizens and yourſelf. They moreover will not only ſerve to light you in the Night, but burn moſt outrageouſly and deſtroy every Thing that is within the Sphere of their Action.

If the Exigence of Affairs requires you to form very large *Balls* of the above Stuff, ſo as to fit the Orifices of *Mortars* or *Great Guns*; you may order them with the ſame Eaſe as we did thoſe of the Firſt Sort. Theſe will be particularly uſeful, to throw into the Enemy's Lines, when they begin their Approaches afar off, or to any of their diſtant Works which are out of the reach of your Arm; that you may by them diſcover what is hid from you under the Veil of Night; and at the ſame time by illuminating all the circumadjacent Country, prevent the Beſiegers Deſigns, or give you timely Notice of them. But I muſt caution you to reinforce theſe great *Balls* with ſtrong Marline, or with a Network of Iron or Latten Wyre, for fear they ſhould be diſperſed in their Projection, or fly to pieces in the Air, inſtead of remaining whole and entire as they ought.

If theſe *Compoſitions* are too dear for you, you may uſe the following, which are cheaper, and to the full as effectual.

Take of *Sulphur* 10 ℔, of common *Pitch* 4 ℔, of *Colophone* 1 ℔, of *Saltpeter* 2 ℔, and of *Suet* or *Tallow* 2 ℔. Melt all theſe, and add to them 1 ℔ of *Coal*, and mix the whole very well together over a Fire; then take it off, and throw 3 ℔ of *Meal Powder* into it; but not all at once, but at ſeveral Repetitions, continually ſtirring and mixing it with the other Ingredients: To this you ſhall add *Tow* as before, and make it up in Balls.

Or elſe take of *Colophone* 1 ℔, of *Sulphur* 3 ℔, of *Saltpeter* 1 ℔, of *Coal* 1 ℔, and a little *Crude Antimony*. Proceed with this as before: This was invented by *Fronſperger*, from whom *Brechtelius* borrowed it.

SORTS III and IV.

Theſe *Light Balls* may be ſo contrived as to be of a Mortal Nature, and by that means ſerve in a double Capacity, of diſperſing Darkneſs, and deſtroying the Enemy. This was formerly put in Execution by the *Dutch* (as we are told by *Diegus Uſanus*, in *Treat.* III. of his *Artillery*, *Chap.* XX.) at the Famous and Memorable Siege of *Oſtend*, from whence they threw *Light Balls* (prepared as we ſhall ſhew you) which did prodigious Miſchief to the Beſiegers. There is nothing difficult in the Preparation of them. You need only take an *Hand Grenado* armed on the Outſide with Muſquet *Balls*, or larger if you will; (ſo that the whole be nicely adjuſted to the Calibre of the *Mortar* or *Gun.*) Having ſtopped up the Vent of your *Grenado* with a Wooden *Stopple*,

you ſhall coat it over with Tow ſteeped in one of the aforeſaid *Compoſitions* to the Thickneſs of two Fingers, and then pulling out the *Stopple* fill it with *Corn Powder*; and coat the Vent of it over as you did the reſt of its Circumference, and rowl it in *Meal Powder*; in ſhort, you ſhall ſecure the Coating upon it with Marline or Wyre, as we ſaid before.

Theſe *Balls* may be likewiſe prepared after this Manner: Take a certain quantity of *Iron Crackers* loaded with *Corn Powder* and *Leaden Bullets*; and with a Wyre, Cord, or Cat-gut, bind them together in ſuch form that their Orifices being alternately diſpoſed, they may appear like a *Radiant Sphere* or an *Hedge-Hog*: the Interſtices between theſe Crackers ſhall be filled up with *Meal Powder* ſteeped and kneaded in Brandy, in which has been previouſly diſſolved ſome common Glue, or any ſort of Gum. In doing this you muſt take care to make it into a perfect Sphere. Then giving it a Coat of Cotton Cloth, dry it in the Sun, or in a Fire-Pan; and proceed with it according to the Method we have already laid down. See more concerning theſe *Balls*; in *Diegus Ufanus Treat.* III. of his *Artill. Chap.* XX and XXI, and in *Hanzelet's Artill. Page* 187 and 211, In *Brechtelius Part* II. of his *Artil. Chap.* I and IV; and *Fronsberger's Artil. Part.* II. *Page* 194 and 196. The laſt of theſe Authors, in the Place I have now quoted, will inſtruct you in the Preparation of a *Ball* which not only burns in a fright ful manner, but alſo ſerves inſtead of *Crow-Feet*. This is the order he obſerves. Take a *Wooden Ball* and arm it all round with ſharp Iron Spikes, taking care that the Points of them which are driven into the Wood tend all to the Center of the ſaid *Ball*, and that their outward Points be about one or two Inches from one another, juſt after the manner of a ſleeping *Hedge-Hog*. Being thus ordered, the Interſtices between the Spikes, ſhall be filled up with Tow ſteeped in one of our Liquid *Compoſitions*, but not ſo as to cover the Points of them, which muſt riſe out to the Height of half a Finger's Breadth above the Tow. For any thing elſe relating to this you may conſult the Author himſelf. Beſides the *Pyrobolic* Writers I juſt now mentioned, you may upon this Subject turn over *Jerome Catanenus's* Examination of *Artil. Page* 37. *Jerome Ruſſel's* Precepts of the modern *Arts* of *War, Page* 11, 32 and 33. And *Eugenius Gentilinus's* Inſtructions in *Artillery, Chap.* LX. and ſeveral others.

CHAP.

CHAP. X.

Of Smoke Balls, *which the* Germans *call* Dampf *and* Blend Kugelen.

WE have oftentimes recourſe to Darkneſs in the Occurrences of *War*, as well as in the Perpetration of ſeveral other Matters; I do not here mean the Gloomineſs and Natural Darkneſs of Night; but ſuch as is Artificial, and which, according to ſome *Rules* of our *Art*, is cauſed to remain for ſome time in narrow Places; whether it be that the Beſieged would blind the Enemy in the midſt of an Attack; or whether the Beſiegers, to favour or facilitate their Aſſaults, would overwhelm the Beſieged with a thick offenſive Smoke, and by that means take them like Fiſh in troubled Waters. To this Purpoſe we have a Way of preparing *Balls* which during their Combuſtion caſt forth a Noiſome Smoke, and that in ſuch Abundance, that it is impoſſible to bear it. You are to proceed thus: Take of common *Stone Pitch* 4 ℔; of *Tar* 2 ℔, of *Colophone* 6 ℔, of *Sulphur* 8 ℔, and of *Saltpeter* 36 ℔: Melt all theſe Ingredients together over a Fire; and then add to them 10 ℔ of *Coal*; 6 ℔ of the Sawduſt of *Pine* or *Fir*, and 2 ℔ of *Crude Antimony*; incorporate all theſe together; which done, throw amongſt them a ſufficient Quantity of *Flax* or *Hemp*: Your *Tow* being ſteeped a due time, and having imbibed enough of this *Liquified Compoſition*, make it up in Balls either to be thrown by Hand, or ſhot from any Machine. As to any thing elſe relating to this Matter, you are to obſerve the *Rules* we have already laid down in the Preparation of *Light-Balls*.

This is the right Method of introducing Night at Mid-day, of intercepting the Sun-Beams, and depriving the Adverſary of the Benefit of Eye-Sight: And the Practice of this is the more lawful, inaſmuch as it is an Imitation of *Nature*, and may with Honour be executed in a righteous *War*. But I baniſh all unlawful Practices from the *Chriſtian Arts* of *War*; and eſteem thoſe *Arts* as infamous, which are founded upon † Charms, Sorcery, and the Invocation of unclean Spirits, together with ſeveral other abominable Superſtitions which muſt be hateful to *God*, odious to Men, and undeſerving the *Title* of *Art*. It is with Horrour that I reflect upon the Faſcinations of the *Moſcovites*, *Tartars*, and even of our *Coſſacks*. But not to dwell on the damnable Abominations, and horrid Impieties, perpetrated by thoſe Wretches with the Aſſiſtance of Infernal Powers; I ſhall only curſorily ſay that they are moſt deeply

† Here we muſt allow for the Prejudice and Superſtition of our Author's Religion.

verſed

verſed in *Sorcery*, and all the *Arts of Hell*, and can raiſe Fogs, Storms, and darken the Light of the Day by means of thick Miſts to ſuch a degree, as to prevent you from ſeeing ſuch Things as are neareſt to you: In ſhort, one would think that they had been perpetual Students under *Zoroaſter* the *Bactrian*; or that they had been bred up in the very Receſſes of *Pluto* himſelf: But as theſe Monſters are forſaken of God, and alienated from his Grace, when they reſort to this *Diabolical Science* for a ſucceſsful Iſſue to their *Wars*, they ceaſe to be under his Divine Protection, and meet with Events ſutable to their Wickedneſs. I could produce many Examples recorded in our Hiſtories to corroborate the Truth of what I have here ſaid; but ſhall content myſelf with giving a ſuccinct Narration of a prodigious and miraculous Victory which God was pleaſed to give us, over † 800,000 *Crim* and *Precopian Tartars*, near a ſmall Town in *Podolia* called *Ochmatow*, in the Year 1644. Theſe *Barbarians* then by their Diabolical Incantations, ſuddenly raiſed ſo thick and frightful a Fog, that we really thought *Nature* had inverted the common Order of Things, and had turned the Day into Night. By this means our *Army* (which was ſmall in Number but great in Heart, under the Conduct of that Thunder-bolt of War, *Staniſlaus Koniecpolski*, formerly the King of *Poland*'s General,) was wrapped in Miſt, and wandered up and down the Country, and marched ſeveral Miles, before we could overtake, or fall in with thoſe Miſcreants, to give them the Chaſtiſement due to their Demerits, and to take Vengeance on them for the Evils they had created us. But we found that the Confidence we had repoſed in Heaven did not prove ineffectual; for no ſooner did we get Sight of the Villains, than the Sun entirely diſperſed the Fog, (under the Covert of which they had committed the moſt horrid Barbarities;) ſo that enjoying compleat Day-light again, we ſoon experienced that Heaven had not abandoned us in our Extremities: In ſhort, to ſay that in few Words, which many have related with Prolixity: I was preſent, I was an Eye-witneſs of the Fact, and our God diſcomfited them.

CHAP. XI.

Of POISONED BALLS.

OF the many laudable *Military Laws* and *Regulations*, which were eſtabliſhed amongſt the ancient *Germans*; and which they obliged their *Pyrotechnicians* to bind themſelves by an Oath to obſerve; the fol-

† In the Book it is 80,000, which is more likely, but the *Table* of *Errata* will have it 800,000.

lowing were none of the laſt nor moſt inconſiderable (ſee *Brechtelius Part* II. and *Chap.* II.) namely; That they ſhould never prepare any *Fire-Works* that ſhould be any ways hurtful to any Perſons or Things: That they ſhould not fire any Cannon in the Night-time: That they ſhould not clandeſtinely hide Fires in ſecret Places: But above all, That they ſhould not prepare any *Poiſoned Balls*, nor uſe any ſort of Venom in their *Compoſitions*, or upon any other Account whatſoever that might affect the Life of Man; for the firſt Profeſſors of our *Art* looked upon all ſuch Actions to be as heinous in themſelves, as they were unworthy of a brave Man and a true Soldier; and ſcorned to deſtroy their Enemies, by ſuch ungenerous and unmanly Stratagems, ſince they might annoy them a thouſand Ways in honourable open Combat: Therefore ſince all Laws, Divine and Human, do in the ſtricteſt manner forbid us in our Civil Capacity to have recourſe to ſuch inhuman Artifices; and ſince they have ordained corporal Puniſhments to be inflicted on thoſe, who to gratify their Luſts, make any hurtful Uſe of Poiſon, Charms, Incantations, *&c.* how much more ought theſe Laws to be obſerved, and how much more are ſuch Practices to be ſhunned in our Military Capacity? Which is not a State of unbridled Licence, or infamous unruly Diſſoluteneſs; but on the contrary, a State of the ſtricteſt Honour, the moſt unſhaken Fortitude, the moſt conſtant Magnanimity, the moſt ſincere Probity; in ſhort, the State of *War* ought to be as it were a Theatre of all Sorts of Virtue. As for private Arms, which are no other than the mere Productions of *Art*, I do not in the leaſt diſapprove of them, nor will I rank them among ſuch Things as are unlawful; for we have the Authority of very great Captains who have put them in practice, and greatly commended them, upon which Account I ſhall venture to ſhew you ſomething farther of them in this little Work: But I will by no means admit *Poiſoned Balls* into the Claſs of *Warlike Inventions*, nor allow the Uſe of them to a *Soldier*, who as he is a Man of Generoſity, and much more as he is a Chriſtian, ought to abhor the very Thoughts of murthering his Neighbour with an invenomed Weapon. Sure, the fertile Malice, and the continual Experience and Exerciſe of Mankind in ſucceſſive Bloody Wars, ever ſince the *Halcyon Days* of the Golden Age, have furniſhed us with Arms ſufficient either to offend our Adverſaries, or defend ourſelves againſt them! Let us not therefore in ſhedding the Blood of our Brethren indanger our own Souls.

But after all it muſt be allowed by what we can gather from the Hiſtorical Records of the Wars in the earlieſt Ages of the World, that theſe *Poiſoned Balls* need not appear ſo heinous to us; and we find that the moſt ſcrupulous Conſciences did not boggle at the Uſe of invenomed Weapons in former Days; nor need the ſtricteſt Chriſtian refuſe or reject them now, provided that he does not uſe them in a War againſt thoſe of his own Faith, but reſerves them for *Tartars*, *Turks*, and

other *Infidels*, who are ſworn Enemies both to the Chriſtian Name and Religion; for thoſe we may ſafely exclude from the Number of our Neighbours. Now theſe *Balls*, are ſuch as in their burſting or burning, taint the Air to a degree of Mortality; for we are taught by Experience, and aſſured by the Learned, that the *Poiſonous Suffumigations* or *Effluvia* of ſuch Things as you muſt uſe for theſe *Balls*, deſtroy the Health of Man, ſtrike at the very Principles of Life, and conſequently extinguiſh the Animal Spirits which keep the Soul confined to the Body. But by the way, you muſt believe, that ſuch Peſtilential Vapours cannot be very effectual, except in ſome cloſe covered Place; for I doubt of the Service of this Contrivance in any open Place, ſuch as a Town or Fort which lies expoſed to the Wind and Flux of the *Air*: Upon the whole, I can ſay nothing certain upon this Head; and can only gueſs at what might be the Effects of it, from what little Knowledge I have in *Natural Philoſophy*; but a few Experiments will inform you of every thing you can deſire to know concerning it.

One Evil generally draws a Thouſand after it: Thus Mankind did not think the bare Invention of *Bows* and *Arrows* ſufficient; (which the Ancients held to be of divine Contrivance, and accordingly *Diodorus Sic.* aſcribes them to *Apollo*, and *Pliny* to *Scythes* the Son of *Jupiter*;) I ſay they did not think their *Arrows* ſimply of themſelves, to be ſufficiently dangerous and hurtful, but they muſt likewiſe be ſteeped in Poiſon as well as their other Arms, to render the Wounds of them the more certainly mortal. We have the Teſtimony of ſeveral Authors to prove the Antiquity and Uſe of this Contrivance; and amongſt the Reſt in *Pliny Lib.* XII. *Cap.* LIII, where he treats of the *Scythians*; in *Paulus Ægin. Lib.* VI. *Cap.* LXXXVIII, where he ſpeaks of the *Dacians* and *Dalmatians*; *Theophraſtus*, *Lib. Plant.* IX. *Cap.* XV, where he diſcourſes of the *Æthiopian* and *Barbarian Wars* in general; *Dioſcorides Lib.* VI. *Cap.* XX. In ſhort, *Virgil* in his *Æneid Lib.* IX. ſpeaks thus:

Ungere tela manu, ferrumque armare veneno.

In *Engliſh*:

In Darts invenom'd, and in Poiſon ſkill'd. *Dryden.*

And in *Lib.* X.

Vulnera dirigere & calamos armare veneno.

In *Engliſh*:

Directing Ointed Arrows from afar;
And Death with Poiſon arm'd. *Dryden.*

And

And in *Lib.* XII.

Non ſecus ac nervo per nubem impulſa ſagitta,
Armatam ſævi Parthus quam felle veneni,
Parthus ſive Cydon telum immedicabile torſit.

In *Engliſh:*

——————— by far more ſlow
Springs the ſwift Arrow from the *Parthian* Bow,
Or *Cydon* Eugh when traverſing the Skies,
And drench'd in pois'nous Juice the ſure Deſtruction flies. *Dryden.*

Ovid de Triſ. Lib. III.
And *Silius* alſo *Lib.* I.
Homer ſpeaks thus in his *Odiſſy.* I.

Φάρμακον ἀνδροφόνον διζήμενος, ὄφρα οἱ εἴη
Ἰοὺς χείεσθαι

In *Latin:*

Pharmacum, mortiferum quærens, ut ei eſſet unde ſagittas oblineret.

In *Engliſh:*

Seeking a deadly Drug wherewith t' infect his Darts.

Thus by the Hint we have taken from the Practice of former Ages, Men dye a Triple Death; for the *Ball* pierces the Body, the *Poiſon* coagulates our Blood, and the *Fire* burns us up.

Certain it is, that the firſt Inventor of our *Gun-powder* is highly blameable, for having introduced an Invention of ſhooting *Bullets* by the means of *Fire*; but thoſe are ſtill worſe who added *Poiſon* to thoſe *Balls*, as if ſimply of themſelves they were not ſufficiently mortal. From hence are derived our *Poiſoned Balls* in Uſe amongſt *Pyroboliſts*, and hence the *Venomous Bullets* in Vogue amongſt the Modern Soldiery. But before we enter in earneſt upon this Subject, I muſt beg your Attention to what *Joſeph Quercetan* ſaith, who was a very famous Phyſician, (*viz.*)

† *That we may not anſwer this Queſtion abſurdly, I ſhall ingenuouſly confeſs, that Lead ſimply conſidered as to its own Nature, has no infectious Effect upon Wounds, nor never has, except it be outwardly infected by any poiſonous Tincture, and that it can be infected no-body will deny: For I*

† Joſ. Quercet. in Libello Sclopetario.

believe

believe every one will allow, (what is generally received amongſt Philoſophers;) *that though Lead is very heavy and groſs with reſpect to other Metals, yet its Contexture is very porous and ſpungy, which is owing to its being compounded of impure and combuſtible* Sulphur; *and of much feculent and droſſy* Mercury, *upon which account it is ſo ſoft and eaſily melted, and copiouſly imbibes any Liquid: If this laſt Quality be attributed to Iron, which is harder and not ſo porous; ſure no one can doubt that Lead will much more readily admit any Infection; and that this is true we have the Teſtimony of many great Authors to evince.*

And a little lower. *Nor do thoſe argue to the purpoſe; who deny that Lead, becauſe diveſted of its Crudity and Groſneſs by being purified, cannot admit any ſtrange Body into it: Indeed Nature informs us, and Experience ſhews, that all Metals purified by Fire, are diſincumbered of their Droſs; and are much refined after an Igneous Operation; for by this Method are Copper, Tin, and even Iron refined; which by being melted by Fire is diſunited from all its Droſſy Particles, and the pure Subſtance of it, which we call Steel, remains collected together, as may be proved from* 4 Meteor. Cap. 6. of Ariſtotle. *Now though it be the Nature of theſe Metals, to be refined by Fire; (as we have ſaid above) and by Fuſion to diſcharge all their Droſs; yet that does not prevent them from imbibing any foreign Subſtance. And who can diſpute but that Steel, which we may rank amongſt the moſt ſolid Metals, may be mixed and tempered with a Subſtance quite foreign to itſelf? Who will affirm that a Mixture of Vinegar, Soot, Water of Mouſe-ear, and of Earth-worms, mixed with the Juice of Radiſhes, is in any reſpect of an Ironiſh Subſtance? Yet if Iron be frequently dipped and quenched in that Liquor, it will acquire ſuch a Hardneſs as is not to be believed but by thoſe who have made the Experiment. On the other Hand, if it be often quenched in the Juice of Marſh-Mallows, Soap, or Hemlock, it will be mollified. It alſo happens to Tin and Lead, that being melted and often cooled in the Juice of the* Squilla *or Sea Onion they are affected in ſuch a manner, that the firſt loſes its noiſy or ringing Quality, and the latter its Blackneſs and Softneſs, which could not be except they retained ſomething of the Spirit and Property of the Liquor in which they are tempered. It is therefore plain, that how greatly ſoever Metals may be purified, and purged of their Droſs, they are capable of imbibing a Subſtance of a different Nature from their own. But it would be folly to ſay that the Mixture of Metalic Spirits which are of the ſame* Genus *or Kind, cannot be more eaſily effected than this: For we ſee that Copper is tinged and turned Yellow by the Spirit of Calamine and of* Tutia: *and on the other hand it is whitened by the Spirit of Arſenic, of Orpiment, &c. From whence we may ſafely conclude, That if Metals (of which* Bullets *are commonly made, and particularly Lead,) ſhould be infected by any Spirituous Subſtance inclining to their own Nature (which may be prepared of ſo many ſorts of Mercurial, Fætid and Deadly Waters, to which are uſually added the Juice of* Aconitum *or Wolf-*

Wolf-bane, of Napellus, *of the* Squilla *or Sea-Onion, of Eugh, of Smallage or Crow-foot, and ſuch like Simples, and venomous Beaſts, which are of noxious Effect upon our Nature) I ſay, being tainted by ſuch like* Compoſitions, *the Wounds they make will be ſo complicated by means of the Venom, that except immediate Remedies be applied they muſt be Mortal. For we have at this Day amongſt us many Mixtures which are ſo Venomous and Peſtiferous, that if the Point of an Arrow be but ſteeped a little in them, and it wounds any Body ſlightly, or only paſſes through any particular Member with a ſudden Celerity, and makes no ſtay in the wounded Part, the Poiſon is ſo ſubtile that it at once diffuſes itſelf over the whole Maſs of Blood, infects the moſt Noble Parts, and inſtantly kills the Perſon.*

Speaking farther on this Subject. *From hence we will conclude that* Balls *may be infected with Venom, not by pouring any into an Hole made to receive it, as ſome would have it; but by immerging the* Bullets *and repeatedly quenching them in ſome of theſe Mercurial Waters or Deadly Juices; by which means they may be corrupted and infected, and (ſuch is the Subtility of theſe Drugs!) invenom the Wounds they make, though they ſhould with the greateſt Velocity pierce through the Body. This has has been experienced upon Animals, which I ſhall account for in my* Book *of* Antidotes *I juſt now mentioned. But by the way I muſt obſerve, that if a* Ball *paſſes very ſwiftly through a* Body, *it cannot ſo well or effectually communicate its Venom; but it moſt frequently happens that* Bullets *lodge in the Wounds, and remain there ſome time before the Surgeon can take them out, which oftentimes is not to be done at all.*

Who then can doubt, but that the Ball *will work its Deadly Effects during the time it thus remains in the* Body? *(The more Spirituous and Subtile they are, as I ſhewed above, the more ſudden are their Effects:) And its Malignant* Effluvia *being conveyed through the Veins, Arteries, and Nerves, they infect the Natural, Vital, and Animal Spirits, and by being blended with them, and by the natural Conteſt which ariſes between them, in which the former always get the better, the Life of the Perſon is extinguiſhed, which purely conſiſted in the lively proper Action of the Spirits. That Poiſons are the moſt pernicious when they are the moſt ſubtile may be gathered from the Bites of Vipers and other venomous Creatures.*

This is all that our Author ſays of the Method of poiſoning *Metallic Bullets*, and their manner of affecting the Human Body.

Thoſe then who would prepare *Poiſoned Balls* may obſerve the Rules laid down by former *Pyroboliſts*, or theſe of our Invention. Take of *Wolf-bane*, or *Wolf-wort*, which the *Italians* call *Luparia*, and the *Germans Wulffvurts*; of *Napellus*, whoſe Root is in form of a Net; (This is a moſt dangerous Poiſon;) preſs out the Juice of it, but take care not to touch it with your Naked Hand: The Juice of it being expreſſed, put it into a capacious Earthen Pan, and expoſe it to the Sun in the

Month of *July*, for the ſpace of a whole Day; that is, as long as the Sun has any powerful Influence upon it; this done, put it in ſome warm cloſe Place, which muſt have no *Onions* or *Garlic* near it, or any other ſtrong-ſcented Thing, for it may be thereby deprived of much of its Strength and Virtue: On the Morrow expoſe it again to the Sun as you did before, and ſo continue to do for the ſpace of a whole Month: And you will have a thick, foul, venomous Subſtance like an Ointment. But you muſt be careful to Air the Place where you lock up your Pan in the Night, for fear the malignant *Effluvia* of this Poiſon ſhould be conveyed through the Noſtrils into the Head, and be attended with Conſequences prejudicial to your Health.

Take moreover 3 or 4 of the rankeſt ſort of Toads, of ſuch particularly as are bred in the moſt ſhady and cold Places; for there they acquire the moſt virulent Venom. Theſe ſhall be put into a Braſs Veſſel like an Alembic, where they may have Room to ſprawl about; which Veſſel ſhall have a Head that nicely fits it, with a Handle at Top of it to lift it on or off; upon one Side of your Veſſel you ſhall have a little round Trough, with a Slit over it, which ſhall be filled with *Oil* of *Scorpions*. Cover the whole up cloſely, and let the Pipe or Spout of your Alembic be received in a Glaſs Phial, which muſt be ſet in a Baſon of cold Water. This done, light a gentle Fire all round it, at the diſtance of one or two Palms, that it may heat by ſlow degrees; and the Toads, as ſoon as they are affected by the Warmth, will immediately ſpew up all their Venom. Thus by Vomiting and Sweating they muſt of courſe become thirſty, and will accordingly drink of the Oil contained in the little Trough to quench their Thirſt, and will ſoon after bring it up again, and it will in the end be diſtilled into the Glaſs Phial aforeſaid. The Fire ſhall be kept up in an uniform Heat for four Hours; then leave your Operation unfiniſhed till next Day, and wait for a Breeze of Wind before you take off the Head of your Alembic; and keeping to the Windward of it, at the diſtance of a few Paces lift off the Head with a long Pole, by running it into the Handle abovementioned; and leave your Veſſel open for 4 or 5 Hours: In ſhort, the noxious *Effluvia* being by that time diſperſed you may ſafely approach it, to take away your Phial. So much for the Preparation of this Poiſon, now for the Uſe of it. Sprinkle over the *Compoſition* of your *Fire-Balls* with this Deadly Extraction, together with the Juices of the Herbs I am going to mention, and charge your *Ball* according to the uſual Way.

You may then add to this: The *Juices* of *Anemony*, of *Torch-weed*, of *Hemlock*, of *Henbane*, of *Mandrake Apples*, of *Mandrake*, of *Napellus* White and Blue, *Monks-hood*, *Paſs-flower*, *Butter-flower*, *Poiſonous Night-ſhade*, *Sea-Onion*, and ſeveral other Simples of this Nature.

The following Things pulverized may do very well, (*viz.*) *Mercury Sublimate*, *White Arſenic*, *Orpiment*, *Cynnabar*, *Minium*, *Litharge*, to which may be added the *Menſtrua* of *Barren Women*, the *Brains* of *Rats*, *Cats*,

Cats, *Bears*; the *Foam* of *Mad-Dogs*, the *Blood* of *Bats*, *Oil* in which has been previouſly drowned a good quantity of *Houſe-Spiders*, of *Quick-ſilver*, *Diagrede*, *Coloquintida*, *Euphorbium*, one and the other *Helle-bore*, of *Thymelea*, *Garden-Spurge*, *Nux Vomica*, and ſeveral other ſuch Things as are of noxious Efficacy.

You may alſo prepare a *Gun-powder*, which will infect the *Air*, and ſuddenly kill thoſe who draw in the Smoke of it; after this manner: Take a *Toad* and ſmother it in *Saltpeter*, and bury it under an Horſe Dung-hill for a Fortnight; then take it out, and proportion it with *Sulphur* and *Coal* as we formerly ordered.

Or you may melt *Saltpeter* over a Fire, and throw a good parcel of *Houſe-Spiders* into it alive, ſo that being ſuffocated they may diſcharge all their Venom into it; you may alſo powder your *Saltpeter* over with a little *Arſenic*; after having incorporated a good quantity of that Drug with it: Then make your *Gun-powder* with it after the uſual manner.

OBSERVATION I.

I believe it will be beſt, if to the *Compoſitions* we have given for *Smoke Balls*, you add the Juices of the Herbs abovementioned, with their Leaves and Roots about half withered; together with the ſeveral other Poiſonous Things we juſt now enumerated; and make them into Balls as before. You might alſo add the outward Bark of Birch; for all ſuch *Ingredients* produce a thick ſuffocating Smoke, and particularly the damp Leaves and Roots of the above Herbs; add to which, that the Smoke they emit being moiſt and heavy, it flags near the Surface of the Ground, and does not ſpring up to any great Height into the Air; but ſmothers and creeps along beneath, and ſpreads through every where, where it can have Admittance: And upon this Account, the beſt Opportunity you can have for putting theſe *Balls* in Execution, is when the Heavens are clouded over, and miſty; during a thick Fog, or in great Rains, or when it ſnows, and in gloomy heavy Nights; for the Air is at thoſe times impregnated with groſs Vapours, which are ‡ impenetrable by the Smoke, and copiouſly interſperſed with Subſtances heavier than itſelf, which ſuppreſs the Fumes of your *Ball*; which would tend upwards in ſerene clear Weather.

OBSERVATION II.

You may arm theſe *Balls* with *Crackers*, to guard them from the Attempts of the Enemy.

‡ It is not owing to the Impenetrability of Vapours, but the Lightneſs of the Air in foul Weather that Smoke does not riſe; for at that Time the Smoke, as ſoon as it is rais'd or exploded from the ſmoaking Body into the Air, falls down again by reaſon that it is ſpecifically heavier than Air; whereas in fair Weather when the Air is heavieſt, and conſequently denſer near the Ground, the Smoke being than lighter than Air, riſes upright by the Laws of *Hydroſtatics*.

OB-

OBSERVATION III.

You muſt be careful, that what you prepare for the Ruin of your Enemies, does not turn to your own Deſtruction; and that inſtead of conveying Death into the Adverſary's Quarters, you be not ſuddenly intercepted by it yourſelf, and overwhelmed before you know where you are. To prevent theſe Self-dangerous Inconveniencies, you ſhall cruſt your *Ball* over with common *Gun-powder* uninfected, and then coat it over with *Tow:* Or elſe putting theſe poiſonous *Compoſitions* into Bags, as is done in the Caſe of *Fire-Balls*, you ſhall fill the Fuzes of them with a common *Slow Compoſition.*

The reſt I ſhall leave to the Diſcretion and Diligence of the expert *Pyroboliſt*; and to ſay the Truth, none of us ſtand in need of Inſtruction in Miſchief; for we naturally have a ſtrong Propenſion to it, and are commonly induſtrious in the Perpetration of it. I ſhall now cloſe up this *Chapter* with conjuring you, never to apply theſe *Balls* after ſuch a manner as to need Repentance after it, or in any reſpect to wound your own Conſcience; always keeping in Mind, that the Love of our Neighbour is inſeparable from the Love of God; and that we have a righteous Judge who wants no Witneſs to our Actions, and who will moſt certainly deal with us according to the Evil of our Ways.

CHAP. XII.

Of STINK-BALLS.

THESE *Stink-Balls* ſeem to be pretty nearly related to the *Balls* we have juſt now treated of; but the Uſe of them is much more lawful, and much leſs pernicious; for theſe only moleſt the Enemy by their Fætid Vapours, wrap them up in artificial Miſt; offend both the Noſe and Head, by their extraordinary Nauſeouſneſs; and pain the Eyes by the Sharpneſs of their Smoke, without any immediate Infection. They are in the main prepared juſt like other *Artificial Balls*, and therefore I ſhall give you the Conſtruction of them in few Words. Take 10 ℔ of common *Ship Pitch*; 6 ℔ of *Tar*; 20 ℔ of *Saltpeter*; 8 ℔ of *Sulphur*; 4 ℔ of *Colophone.* Melt all theſe over a ſlow Fire in an Earthen Pot: And being melted, throw into them 2 ℔ of *Coal*, 6 ℔ of the Raſpings or Parings of *Horſe*'s or *Mule*'s *Hoof*; 3 ℔ of *Aſſa Fætida*; one ℔ of *Sagapenum*, which the *Latins* call *Sacopenium Putidum*; and ℔ ß of *Spatula Fætida*, or *ſtinking Gladwin:* Incorporate all the above *Ingredients* well together; and add to them as much *Flax* or *Hemp* as is ſuffi-

cient to abſorb them: Then whilſt the *Tow* is warm, make it into *Balls*; in fine, you ſhall obſerve the very ſame Order with theſe, as we have in general directed for *Light-Balls*, *Smoke-Balls*, and *Poiſoned Balls*.

COROLLARY.

What Man is there who knows not that the Air we breathe may be dangerouſly tainted; and that contagious Diſtempers are commonly generated by the Corruption of that Element? Thus a beſieged Place being no other than a Theatre of all the Evils Mankind can be afflicted by; it is amongſt other Inconveniences ſubject to peſtilential Vapours, ariſing from the ſtinking *Effluvia* of Carrion, the Putrefaction of rotton Carkaſſes, and other Filths which they cannot remove out of the Town. I ſhall not here undertake a Rehearſal of the many Examples of Sieges, in which the Beſieged have been more abundantly cut off by Peſtilence than by Steel or by Fire: But to come to the Point in hand, I ſay, that the corrupted Air of Beſieged Places may not only proceed from Natural Cauſes, but may alſo be introduced by the Artifices of the Beſiegers. The putrid Stinks within are thoſe of the unſavoury rotten Breaths of the *Famiſhed* and *Over-fatigued*, the corrupted Bodies of the *Slain*; Dunghills, and many other Things from whence unwholeſome Vapours are exhaled. Now the Beſiegers may add to the Natural Infection of the Town, or even originally cauſe it by means of ſeveral Sorts of Poiſoned Infectious *Balls*; or by throwing with the Ancient Machines (if you will admit them again into Service) the Putrid Carkaſſes of Soldiers, or any ſort of Carrion; together with great Tubs full of the Emptyings of Privies, and the like, which may be toſſed into the Beſieged Place. Hiſtory will inform you of many ſuch like Practices amongſt the Ancient *Romans*, and the other Warlike Nations of their Time: But not to look ſo far backwards, we have a very modern Inſtance of this in the Chronicles of the City of *Liege*, where we met with this Remark (viz.) *The* Liegois *vigorouſly aſſaulted the Caſtle of* Argenteal, *throwing great Stones into it with* Baliſtæ, *together with Earthen Veſſels full of melted Metal, Red-hot Iron, and Excrements in abundance.*

From hence we may draw theſe Concluſions: *Firſt*, that the Air of a Town may be terribly infected; and corrupted to that degree as to oblige the Beſieged to a more ſpeedy Surrender, or at leaſt urge them to a Parly ſooner than they deſigned.

Secondly (which is well worth our Obſervation) That by the Help of the Antique Machines, you may not only ſling the Dead Carkaſſes of Men and Horſes, together with large Veſſels full of Fiery, Flaming, or Scalding Matter; but alſo ponderous round Stones, vaſt Splinters of Rocks, and other Bodies of immenſe Weight. Amongſt the many Teſtimonies which might be brought to corroborate this Fact, I ſhall give you only one, which I have taken from *Paul. Emil.* in his Hiſtory of

of the *Siege* of † *Ptolemais* in *Paleſtine* by *Philip* King of *France* and *Henry* King of *England* (namely) *they broke in the Roofs of the Houſes with great Stones ſhot from their* ‡ Tollenons, *which were the Bane of the Inhabitants.*

Silius alſo mentions them in *Lib.* I.

Phocais effundit vaſtos Baliſta Molares,
Atque eadem ingentis mutato pondere teli
Ferratam excutiens ornum media agmina rupit.

In *Engliſh:*

——— Then from contracted Strings,
Stones of vaſt Bulk the *Phocæan* Engine flings,
Or changing Weight whole Trees with Iron bound,
Ejects, that breaking through, the Ranks confound. *Roſſ.*

Judge now of their Weight by their ſtrange and frightful Execution. We moreover find in the *Annals* of *Spain* (according to *Lipſius)* a Story of a Young Man called *Pelagius,* who was a Perſon of great Modeſty, and being earneſtly ſollicited by a Beaſtly King to commit that Crime with him which will not bear to be named, he accidentally ſtruck him whilſt the Brute was careſſing him; upon which the Infamous Monſter of a Prince ordered him to be put upon a *Baliſta,* and thrown over the River *Betys* acroſs the Rocks. But I ſhall ſpeak more at large of this in its proper Place; where (as I have ſaid before) I ſhall give you the *Figures* of the Ancient Machines with all the Accuracy the Remarks I have made upon the Accounts given of them could ſuggeſt to me; in which I have gone ſo far as even to make Models of them with my own Hands, to try their Effects, and to ſee whether Authors have had a due regard to Truth in what they have related of them. I only mention them here, to remind you that the Beſieged may expeditiouſly and conveniently gall the Enemy, with putrified Carkaſſes and an infinite Number of Veſſels of all Sorts of Figure filled with Venomous or Smoky *Compoſitions,* and all other *Pyrobolical Projectiles,* which we ſhall touch upon in the following *Book,* and particularly ſuch as are ordinarily uſed in the Defence of Places. Let Men of Senſe and ſound Judgment conſider a little upon theſe Things; and if they can convince me that I am out of the Way, after all I have ſaid and quoted upon this Head; I ſhall readily ſubmit to their reaſonable Demonſtrations: But as I apprehend myſelf to be in no danger of ſuch Conviction, I ſhall to the lateſt Hour of my Breath regret the Inactive State of ſome of the *Antique Machines.*

† This Town is now called *St. John D'Acre.* ‡ Theſe were the ſame with *Baliſta.*

CHAP.

CHAP. XIII.

Of a Ball, *which* Fire-Workers *call a* Death's Head.

TAke a perfectly round *Ball*, of Iron or any other Metal, of ſuch Diameter as conveniently to fit the Calibre of the Piece of Ordnance you intend to uſe. The Body of it muſt be hollowed out Cylindrically, which it may be to the Depth of $\frac{2}{3}$ and the Breath of $\frac{1}{4}$ of its Diameter; The Sides of it ſhall likewiſe be bored in ſeveral Places, all which Borings ſhall tend towards the Hollow Cylinder in the Middle, but ſhall not center in it quite, and ſhall only correſpond with it by fine Holes or Fuzes. Theſe little Fuzes ſhall be filled with fine *Meal Powder*; and the large Cavities ſhall be filled with *Corn Powder* and *Leaden Shot*, and Wadded well with *Paper* or *Tow*. Fig. 156.

The great Hollow in the Middle ſhall be filled with *Meal Powder*, to which ſhall be added $\frac{1}{4}$ of *Coal*, and ſhall be ſprinkled over with *Brandy* or *Oil* of *Petrol*; or elſe it may be filled with one of the *Compoſitions* I have given for the Fuzes of *Grenado's*. In ſhort, the whole ſhall be coated with a Tarred Cloth, leaving only the Vent of it open. When you Fire this *Ball* you ſhall let the Orifice of it reſt immediately upon the *Powder* in the Piece, without the Interpoſition of any Wadd between them: See *Fig.* 156.

Obſerve here that theſe *Balls* may be made of Wood alſo; but in this Caſe you muſt thruſt ſuch *Crackers* as you ſee in D, *Fig.* 151, into all the Cavities but that in the Middle; in a word, it ſhall be reinforced with an Iron Bandage, to prevent its breaking to pieces at the time of its Projection, and ſo prove of no Effect. Fig. 151.

CHAP. XIV.

Of a Ball *commonly called the* Pyroboliſt's Valet *or* Attendant.

THE *Ball* which you ſee repreſented under *Fig.* 157, has got the Name of the *Fire-worker's Servant*, from its conſtant readineſs to do Service, in which it differs from all the reſt. Now this gentle Servant is very ſimple in Nature, and eaſily governed and conſtructed. You need only take a Wooden Cylinder whoſe Diameter is equal to the *Calibre* of your Piece of Ordnance: Its whole Height ſhall be 3 of its Diameter, and one End of it ſhall terminate in a Multilateral Pyramid; Fig. 157.

mid; which Pyramidical Part of it ſhall be another Diameter. The Sides of it then ſhall be bored all round with Holes of the Diameter of two Fingers Breadth, each of which ſhall correſpond with that in the Middle of it. Into theſe Holes you ſhall thruſt ſuch *Crackers* as we juſt now mentioned (ſuppoſing it to be made of Wood.) The Cavity in the Middle ſhall be filled as we directed above for the Preceding *Ball.* Its Point ſhall be armed with Steel, that it may ſtick faſt into any thing it falls upon or ſtrikes againſt. Farthermore, it ſhall be reinforced with three Iron Rings, *(viz.)* one round the Top of it, one round the Middle, and a third round the Foot of its Pyramid; By this means it will be able to withſtand the Shock of the Flaſh: As to any thing farther relating to this, it muſt be ordered juſt like the Preceding *Ball.*

CHAP. XV.

Of the Pyrotechnic Manipulus *or* Bundle.

IT often happens that you are ſo ſuddenly ſurprized and reduced to ſuch Extremities, that you have not time to prepare theſe Artificial *Balls* in due Form: And in ſuch Exigents this *Manipulus* may be recurred to, which is no other than a Bundle of *Iron* or *Copper Crackers* of
Fig. 151. the ſame you ſee repreſented Numb. 151, under the Letters F, G, and I; (no matter whether they be Triple, Double, or Single) they muſt be charged with *Corn Powder* and *Leaden Balls*, and bound firmly together with Wyre or Cat-gut, ſo that they may not be torn aſunder by the Violence of the Flaſh of the Gun, but remain collected in a Body, and perform their Effects together. They ſhall be primed with one of the *ſlow Compoſitions* we formerly gave. In ſhort, theſe *Bundles* may be of various Sizes, according to the Calibres of the *Mortars* or *Guns* they are to be projected from: They ſhall be put naked into the Piece, and reſt immediately upon the *Powder* in it.

CHAP. XVI.

Of certain Pyrotechnic Balls *which may be privately hid, and ſo ordered as to perform their Effects at certain Prefixed Periods of Time.*

WE have elſewhere acquainted you that the Old *German* Captains deteſted the Uſe of clandeſtine Fires, and baniſhed them from their *Arts* of *War*, as unjuſt and ungenerous Inventions, and accordingly forbad their *Pyroboliſts* and *Fire-Workers* to prepare any of them: But notwithſtanding this laudable *Injunction*, we find in *Hiſtory* that theſe *Fires* were put in Execution even when *that* and ſeveral others of the ſame Tendency were in their Prime, and full Force: In our Age indeed it ſeems as if theſe and ſeveral other old Inventions muſt make their *Exit*, and give Place to new ones formerly unknown; and accordingly theſe *Balls* are upon the Point of Expiration; ſo that were they not recorded in our Writings, the very Remembrance of them would be blotted out in a very few Years more. Now ſince our Forefathers found them of Uſe in their Days, (however unfair they might deem them) why ſhould they not be of ſome Service to us as well as to them? A good Head and a little Diligence, would turn them to ſome Account at proper Times and Places. I find ſeveral ways of conſtructing them both as to Form and Size, according to the Exigence or Nature of the Affairs we would employ them in: For thoſe which are to be hid in Houſes, Cloſets, Barns, *&c.* muſt be of one ſort; thoſe which are lodged in *Powder Magazines* and *Arſenals* into which we have free Acceſs muſt be of another kind; and thoſe which are conveyed into Waggons, Trunks, Casks, or any Baggage which is going into the Enemy's Forts and Garriſons muſt be of a Third Species. I ſhall only give an Example of them in three *Balls* of different Sorts; the Firſt of which, diſtinguiſhed by the Letter A, in *Figure* 159, bears an exact Reſemblance to a common *Fire-Ball*; and does not ſeem to differ from it in any particular excepting its *Match*, which is wound round it (provided it is upon any Plane) in Spiral Folds. This *Match* muſt be of that ſort which neither ſmokes nor yields an offenſive Scent, the Preparation of which we taught you in *Book* II. *Chap.* XXVII. One of the Ends of this *Match* is ſtuck into the *Vent* of the *Ball*, and the other which is lighted is coiled round it, ſo as to have its Revolutions at a convenient Diſtance from each other, that it may burn gradually out from one End to the other, without catching Fire in more Parts than one. The Length of it muſt be proportioned to the Time you deſign it ſhould burn, or to the Period you prefix for Fig. 159.

the Combuſtion of your *Ball:* There will be no Difficulty in doing this, if you know exactly what Length of your *Match* will be conſumed every Quarter of an Hour: Thus if you propoſe that your *Ball* ſhould perform its Effect in two Hours after it is hid, and you are aſſured that about half a Foot of *Match* conſumes every Quarter of an Hour, you may readily conclude that in this Caſe you muſt allow 4 Foot of *Match.*

The other *Ball,* diſtinguiſhed by B, is commonly made of Wood (though it may be made of Iron or Braſs like a common *Grenado,* but then it muſt be filled with *Corn Powder* only, for Reaſons above given.) It muſt have a Serpentine or Spiral Fluting or Channel wrought in its Convexity from the Bottom to the Top, in which Fluting or Hollow you muſt glue your Match from one End to the other of it, as may be ſeen in C. This Sort is much better contrived than the Firſt, becauſe the Match is as it were a conſtituent Part of the *Ball,* and does not take up ſo much room as the former.

In ſhort, the Third *Ball* (D) of this Kind has nothing extraordinary in its Conſtruction. It has only a Stick in its *Vent,* round which is twiſted a *Snake* of *Match,* which muſt be of due Length (as I obſerved before) and firmly glued to the ſaid Stick, that it may not unfold itſelf in burning.

Theſe *Balls* ſhould be filled with very ſtrong *Compoſitions,* and ſuch as are very pregnant of Fire; as for Example, ſuch as was anciently the *Grecian Fire,* the *Compoſition* of which I have given you from *Scaliger* in our *Chapter* of *Fire-Rain.* Now this Mixture will be ſufficiently violent, as well becauſe of the *Igneous Ingredients* it is compounded of, as on the ſcore of the particular Manner of its Preparation; for Experience evinces that a Dung-heat has a wonderful Power of transforming, and as it were vivifying whatever is buried under it; in which it imitates Natural Heat: That *Genial Mother* who works ſuch Wonders, and has reſerved to herſelf a Power of putrifying, which is altogether ſurprizing! For we find that the Animals generated from Putrifaction, are as various as the ſeveral Things that are putrified. Whoever reflects upon this, and conſiders it attentively, may turn it to very good Advantage. Upon this Account, I think that ſuch a *Compoſition* would be preferable to all thoſe which only have their *Ingredients* mixed up together without any farther Preparation; though I muſt here make an Exception with regard to *Gun-powder,* which being beaten and pounded for a conſiderable time, becomes extreamly vehement (as I have elſewhere obſerved) and is transformed into a perfectly Light and Volatile Subſtance.

Brechtelius in *Book* II. and *Chap.* II. of his *Artillery,* gives us the following *Compoſition* for the Uſe of theſe *Balls.* Take 3 lb of *Powder,* and one lb of *Sulphur;* reduce them to a very fine impalpable Meal, and incorporate them well together: Then add to them a little *Colophone,* and ſome Drops of *Turpentine;* and knead them all up in a Dough or

Paſte

Paſte with *Linſeed Oil* and *Brandy*: Thus the whole being perfectly incorporated, fill your *Ball* with it. However I think it will be better to uſe ſomething of the Nature of the *Grecian Compoſitions*; becauſe our clandeſtine Fire is nearly related in its Effects and Operations to the foreſaid *Fire*; as we are informed by ſeveral creditable Authors: As to the *Ingredients*, I do not apprehend that they can be wanting to you, either on the Score of their Scarcity or Price. Remember that inſtead of *Match*, you may uſe ſome of that *Pyrotechnic Slow Tow*, which *Brechtelius* mentions in *Part* II. *Chap.* II. of his *Artillery*, and which we have given you in our *Second Book*.

CHAP. XVII.

Of RED-HOT BALLS.

THE Practice of ſhooting *Red-hot Iron*, is far from being of modern Date; for long before the Invention of our *Artillery*, it was the Cuſtom of the *Ancients* to defend themſelves with *Red-hot Iron*, as is teſtified by *Diodorus Siculus*, who ſaith: *That the* Tyrians *threw great Bodies of* Red-hot Iron *into the Works of* Alexander *the* Great. An uncertain Author alſo ſpeaks to this Effect in *Suidas*: *They threw from Eminencies whatever was Liquid or Fuſible, ſcalding hot upon the Enemy. And amongſt other Things* Red-hot Pieces *of* Iron, *which they kept ready for thoſe who attempted to ſcale their Walls.* † *Vitruvius* alſo ſpeaking of the People of the Town of *Marſeilles*, ſaith, *That they threw* Bars *of* Red-hot Iron *from* Baliſtæ *to burn the Beſiegers Works.* If you would be farther informed upon this Head, you may conſult thoſe Authors, whoſe Teſtimony we have all along recurred to. But to dwell much upon the great Requeſt *Red-hot Balls* have been in ſince the Invention of *Gun-powder*, or to recount the Havoc they have made, or to relate their frightful Executions in the ſeveral Occurrences of *War*, would be giving of myſelf a needleſs Trouble; ſince none can be Strangers to this matter, but thoſe who have never borne Arms, or never dealt in *Hiſtory*, which does furniſh us with many Examples of this kind: Amongſt which ‡ *Emanuel de Meteren* in his *Hiſtory* of the *Low-Countries*, relates the following Inſtance to have happened at *Rhinburgh* when it was beſieged by the Admiral of *Arragon* in the Year 1598, (viz.) *A Red-hot Ball* (it muſt have been *Red-hot* though he does not expreſly ſay ſo) *being ſhot from the Beſiegers Batteries againſt a Tower where the Beſieged kept their* Gun-powder, *it went through the Wall of it which was but a Brick thick, and fell into a Barrel of* Powder; *which imme-*

† Vitruv. Lib. X. Cap. XXII.

‡ Em. de Met. Lib. XX.

diately

diately taking Fire accended all the reſt, which were to the Number of 150; *upon which enſued ſuch a prodigious Clap, and ſuch a general Conflagration, that it not only blew up the Tower it was kept in, but ſet Fire to the moſt lofty Houſes in the Town, and ſhattered thoſe in the Neighbourhood of it in pieces; threw down a great Part of the Town-Wall, and what is ſtill worſe, the moſt conſiderable Part of the Soldiers and Inhabitants, together with the Governor, were buried under Ruins; in ſhort, there was hardly any Body in the Town eſcaped without being ſo miſerably diſabled, as to be unfit ever to bear Arms again, or incapacitated to work at their Trades. Paulus Piaſecius* Biſhop of *Premiſlaw*, who wrote our *Annals*, has the following Narration. *From thence marching his Troops* (he ſpeaks of the Admiral of *Arragon) towards the* Rhine, *he beſieged* Rhinburgh *a Place belonging to the Archbiſhop of* Cologne, *which had been formerly in Poſſeſſion of the* Spaniards; *but during the time that the Arch-Duke* Albert *was in* France, *it was reduced by the* Hollanders, *who afterwards kept a ſtrong Garriſon in it. The Beſieged at firſt made a brave Reſiſtance; but a* Cannon Ball *being accidentally ſhot into a* Powder-Magazine *there enſued a general Conflagration and Ruin; it made a great Breach in the Town Wall, upon which the Beſieged were obliged to Capitulate, who being allowed good Quarter, and permitted to march out with their Baggage, they evacuated the Town.* But † *Diegus Uſanus* gives us a Relation almoſt as Tragical as this, to which he adds an odd Accident that befel a *Dutch* Ship which was going into *Oſtend* with a Lading of *Gun-powder*; (namely) that ſhe was blown up by means of a *Cannon Ball:* This Author is of Opinion, that theſe two Caſualties were not owing to what we apprehend, but that the *Ball* accidentally ſtruck againſt ſome Stone, Piece of Iron, or ſome other hard Subſtance, and ſent forth abundance of Sparks, which were the Cauſe of theſe melancholy Accenſions. But I am rather inclined to believe (in which *Emanuel de Meteren* ſeems to agree with me) that it was ſome *Red-hot Ball* which was ſhot with Deſign to perform ſuch an Effect; for it is not to be imagined that becauſe a *Ball* has pierced through a ſingle Brick Wall, or a Ship's Plank, or ſtruck upon the Head of ſome Nail, that it can ſtrike ſuch a Fire as to be able to penetrate through a Powder Barrel: No; it is more probable that ſome Deſerter going over to the Enemy, had informed them where ſuch and ſuch *Powder* was lodged, or what the Ship was laden with, and that thereupon they took the proper Meaſures to blow up the *Gun-powder* which is moſt uſually done by *Red-hot Balls*; for there is no kind of *Ball* (though our *Art* has invented many) which is ſo convenient for conveying Fire and Deſtruction as theſe; for they at once perform the Office of a *Cannon-Ball* and of a *Fire-Ball*; add to which, that it cannot be perceived during the time of their Projection, whether they be Red-hot or not.

† Di. Uſa. Treat. II, of his *Artillery*, Dialogue XII.

Here we might repeat what we formerly quoted from *Lipſius*, concerning the *Fire-Balls* which are commonly ſhot from *Cannon*; for I am of his Mind when he thinks that *Red-hot Balls* might be as effectually ſerviceable as *Fire-Balls*; and I conceive that what ſo grave and famous a Perſon ſaith ought to have its due Weight with us. Now to ſhew that this Opinion of his is not ill-grounded, our Hiſtorians who have recorded the mighty Exploits of our glorious Kings have made no Diſtinction between them; but have promiſcuouſly uſed the Words *Kule Ogniſte*, to ſignify all thoſe *Balls* which are contrived to burn Edifices, Intrenchments, Paliſades, and other Wooden Defences of *War*, which anſwer to the *Latin* Expreſſion *Globus Igneus*, *vel Ignitus*, or a *Fire-Ball*; this (though improperly enough) is applied to *Red-hot Balls*: Moreover, the Signification of the *Latin* Words *Igneus*, *Ignitus*, and *Candens*, is Synonymous, and they are indifferently uſed to expreſs one and the ſame Thing.

I do not think it worth while to waſte more Time in perſuading you that *Red-hot Balls* are very uſeful and ſerviceable upon Warlike Occaſions, that being a Point which has been indiſputably demonſtrated by many Authors before me; I therefore have nothing more to do than to tell you what is obſerved in ſhooting them.

Firſt you muſt charge your *Gun* with the uſual Requiſite of *Powder*, and ram it down with a Wooden Tompion that exactly fits the Chaſe of the Piece, the Thickneſs of which ſhall be equal to, or not much leſs than the Diameter of the *Ball*; and for the more Security, you ſhall add to it a Wadd of Hay, Straw, or Tow, or (what will be much better) of the Sinews of Animals ſpread out like Tow, and previouſly moiſtened. This done, you muſt carefully ſpunge the Inſide of the Piece for fear any Grains of *Powder* ſhould be accidentally ſcattered in it; and then, point or level your *Gun* at the Place you deſign your *Ball* for, according to Art; and let it remain in that Poſition till you put in the *Ball*, which ſhall be perfectly round, and run freely down the *Chaſe*: You may take hold of it with Iron Tongs or Pincers, from the Forge, which muſt not be far from the Battery: As ſoon as you think that it is ſlipt down upon the Wad, fire off your Piece.

There are thoſe who drive Boxes made of Iron or Copper Plates into the *Gun*; and others who uſe Clay, and then ram the *Ball* as faſt as they can towards the *Powder*, with a *Rammer* armed at the End with a Copper Plate; but the Firſt Way I have here mentioned is by much the ſafeſt, and leaſt ſubject to Danger.

CHAP. XVIII.

Of Pyrotechnic Hail, *by which are meant* Caſe Shot, *or* Cartouch Shot, Partridge Shot *and* Grape Shot.

WHAT *Pyroboliſts* mean by *Pyrotechnic Hail*, is a Parcel of little Hard Bodies, which being projected perform an Effect after the manner of Natural Hail; but it is ſomewhat more Hard and Perilous; our *Artificial Hail* being moſtly of coarſe Gravel, River Pebbles, or any Stones of the bigneſs of a Pigeon's Egg, and ſometimes of Leaden Balls or Slugs, or little Bits of Iron, and all ſuch like Things.

This *Hail* is uſually ſhot at the Enemy, with our *Mortars* or *Hobbits*, and other *Field Pieces.*

This *Shot* is variouſly ordered; for ſometimes it is ſhut up in *Wooden*
Fig. 160. *Caſes* or *Cartouches*, as you ſee in *Fig.* 160, under the Letters A and B; and ſometimes in Copper or Iron Boxes, as you ſee in D and E; finally, you muſt run Pitch into the Interſtices of it, to keep the *Bullets, Stones*, or whatever elſe it is compoſed of, together.

The Length of the *Caſe* or *Cartouch* ſhall be 1 ½ or 2 Diameters at moſt of the Chaſe of the *Gun* or *Piece* it is to be projected from; and the Bottom of it ſhall be half a Diameter in Thickneſs, the Lid or Cover ¼, and the Sides $\frac{1}{16}$ only. I here ſpeak of Wooden Caſes; for thoſe which are made of Metal, muſt be quite different from the abovementioned in every reſpect but their Length.

There are thoſe who do not take ſo much Trouble with this kind of *Shot*: They firſt load the *Piece* with *Powder* as uſual, and ram it down with a Wooden Tompion; upon which they pour in *Partridge* (as this *Shot* is ſometimes called) to the Height of an *Iron Bullet* of the ſame *Calibre* with the *Piece*, and add a common Wadd upon it.

Others put it into ſtrong Canvaſs Bags. I have repreſented one Sort to you in the *Figures* G and H, which is very pretty, and in the Form of a Bunch of Grapes: The ordering of this is very eaſy. In Letter F you have a Wooden Tompion with a perpendicular Rod ſtuck into the Center of it. The Bottom of the Bag muſt be ſewed up pretty ſtrongly, and then filled with *Leaden Bullets* of 2, 3, or 4 *Ounces.* You muſt then faſten your Bag at Top, and paſs Marline over all the Interſtices of the *Balls*; in ſuch Form that the Circumvolutions of it croſſing one another, it may look like a Net. This done; dip the whole into Pitch.

Again;

Again; there is a Way (which is none of the moſt deſpicable) of making it into *Balls*, as may be obſerved in the Letter C, which is done thus.

Take of *Pitch* 4 Parts, of *Colophone* one Part, of *Wax* one Part, of *Sulphur* two Parts, and a little *Turpentine*: Melt theſe over a ſlow Fire, and being melted, throw into them 8 Parts of *Quick-Lime*; 4 Parts of *Powder* of *Tiles*; and one Part of the Filings of *Iron* or *Hammer-ſcales*. Incorporate all theſe *Ingredients* well together: Which done, add to them as many *Pebbles* or *Muſquet-Balls* as are needful. Whilſt this *Compoſition* is cooling, make it up in Balls, that may exactly fit the *Gun* or *Mortar* you intend to uſe.

There are thoſe who make this *Shot* into Balls with *Plaſter*, or *Powder* of *Alabaſter*: But I ſhall refer you to *Stone-cutters* and *Statuaries* to inform you, how you are to manage theſe Materials. Others again, make it into Balls with Dirt or Clay, which they ſet to dry in the Sun and Wind.

This *Shot* or *Hail* (as we have called it) is particularly uſeful in Open Pitched Battles; or when the Beſiegers are reſolved upon a Storm; or endeavour to poſſeſs themſelves of an opened Gate; or mount a Breach; it is then that the *Cannon* and *Mortars* play this *Shot* in abundance, to introduce Death and Confuſion among the Aſſailants.

The Requiſite of *Powder* for projecting theſe, muſt be the ſame as is ordinarily allowed for a common *Bullet*.

CHAP. XIX.

Of ſeveral Sorts of Chain *and* Bar-Shot, *&c.*

I Here preſent you with *Figures* of ſeveral Sorts of *Chain* and *Bar-Shot*, and ſome other dangerous Weapons of a like Nature; which are moſt commonly uſed in Sea-Fights to diſable the Enemy's Ships, by cutting their Rigging, Sails, Yards, Maſts, Rudders; and for deſtroying ſeveral other Parts of a Ship, the Names of which are known to Seamen only: And at the ſame time they do Execution upon the Ship, they may deſtroy the Ship's Company.

The ſeveral Kinds of this *Shot* may be eaſily apprehended by the *Figures* 161, 162, 163, 164, 165, 166, 167, 168 and 169. *Fig.* 170 repreſents a Box or Caſe into which the five Sorts of *Chain-Shot* (which you ſee) are put when they are projected. That *Trundle-Shot*, which you ſee in *Figure* 161, has its particular Box, which you ſee repreſented beneath it, and diſtinguiſhed by A; the three others need no Addition to them when they are fired away. Fig. 161, 162, 163, 164, 165, 166, 167, 168, 169, 170.

All

All theſe will do terrible Execution in Skirmiſhes, Aſſaults, and powerful Incurſions of the Enemy, *&c.* In ſhort, the two laſt, in *Figures* 168 and 169, will be uſeful in deſtroying Paliſado's, Fraiſes, Crow-Feet, *Chevaux de Friſes*, Herſes, Portcullices, Faſcines, and all kinds of Wooden Defences and Coverts. In fine, they will ſerve to ruin, and overſet *Baskets*, *Gabions*, *Batteries*, *Chandeleers*, &c.

I apprehend that it will be unneceſſary for me to inſtruct you in the particular Uſes of theſe Things, ſince a little Practice and Study will inform you more to the Purpoſe, than all the Rules and Directions I could lay down.

OF THE

GREAT ART

OF

ARTILLERY.

PART *the* FIRST.

BOOK V.

Which treats of ſeveral Warlike Machines, *fix'd and moveable,* Bodies *of* Fire, *and other* Pyrotechnic Arms, *as well for War as Recreation.*

IN this *Book* you will have a Collection of the principal and moſt artificial Inventions in all *Pyrotechnics,* one Part of which ſhall be under the Denomination of *Machines* or *Engines*; the other, of Bodies of *Fire*; ſome of *Miſſiles* or *Projectiles,* and *Artificial Arms,* not to mention the particular Denominations of each of them. We might indeed range them all under the general Title of *Machines*; the Signification of that Word (according to the Definition of *Aſconius)* being applicable to *all ſuch Things wherein the conſtituent Matter is not ſo much conſidered, as the Artifice of the Invention, or the Skill of the Inventor:* And we may ſafely ſay of the Productions of our *Art* in general, that they can boaſt of the Fertile and Judicious Conceptions of their Inventors: From hence it is that the *Latins* called *Architects* and *Engineers, Igeniarii* or *Ingenioſi,* in which the *French* have imitated them, by calling all ſuch Perſons *Ingenieurs*; (and the *Engliſh* have not much deviated from them, in calling them *Engineers*;) but this is no Place for tracing up the Etymology of this Word to its Source.

Upon the whole, the Words *Machine* and *Machination* are of very extenſive Import; for under them are couched all Frauds, under-hand Practices, Stratagems, Plots, Ambuſcades &c. from whence it is that *Cicero* the *Prince of Orators* ſays, † *Iiſdem Machinis ſperant me reſtitutum poſſe labefactari, quibus antea ſtantem perculerunt:* 'They expect to ſub-'vert me by the help of the ſame *Machines*, wherewith they threw me 'down before from my Proſperity;' here you are to underſtand the Word *Machine* to ſignify deceitful or malicious Efforts. *Brutus* alſo ſaith: ‡ *Omnes adhibeo Machinas ad tenendum Adoleſcentem:* 'I leave no *Machine* un-'worked to prevail upon that Young Man:' Meaning thereby, that he left no Means unpractiſed to reſtrain his turbulent unruly Spirit. Now I apprehend that I ſhould have much more Reaſon to apply this Word to ſignify all our Pieces of Ordnance, whether Ancient or Modern, ſuch as *Cannon, Culverins, Chambered Peices*, and other ſuch like: Under this Denomination we might alſo range *Muſquets, Arquebuſſes*, or (as they were formerly called) *Murthering Pieces*, and all other portable *Fire-arms*; as alſo *Mortars* and *Petards*, which bear a near affinity in Effect to the *Machines* of the Ancients, ſuch as their *Rams*, * *Onagri*, *Baliſtæ*, *Catapultæ* and *Scorpiones*, with which they beat down Walls, deſtroyed the *Enceints* of Towns, and from whence they projected offenſive Weapons. But *Lipſius* (and ſeveral other Authors) has not honoured them with the Title of *Machines*, and only calls them by the general Word *Tormentum*, which is now uſed to ſignify our *Cannon* and Pieces of *Ordnance*; reſerving *Machine* for Battering *Towers*, || *Plutei*, § *Muſculi*, running or rowling *Towers*, ⸸ *Sambucæ*, *Tollenones*, and all ſorts of Scaling Engines or Aſcents, and all thoſe Things, under which were fixed the *Tormenta* beforementioned, and under which they covered their Soldiers when they attacked a Fortreſs or ſcaled a Wall. In truth, he was in the right to make ſuch a Diſtinction between them, ſince their Functions and Offices were ſo different: Juſt as here we uſe this Word *Machine* to ſignify only, certain Artificial Inventions or complicated Heaps of Artificial Fireworks, ſuch as *Palaces, Triumphal Arches*, and other Edifices adorned according to the Rules of *Civil Architecture, Caſtles, Towers, Columns, Pyramids, Obelisks, Coloſſuſes, Medallions*, ſeveral ſorts of Human Statues, and the Repreſentations of ſeveral Animals, together with *Fountains, Terreſtrial* and *Aquatick Fire-Wheels*, with ſeveral other Things of this kind, which we ſhall treat of in their proper Places; all which we have called *Machines*, not ſo much on the ſcore of their Forms (which are vaſtly various) as on account of their Effects, with regard to which they not only walk hand in hand with the *Machines* abovementioned, but likewiſe exceed them very conſiderably. We might indeed have taken in all manner of Pieces of Ord-

† Tull. Cicero pro Dom. 17. ‡ Brut. Epiſt. XVIII. * Theſe were *Engines* for ſhooting of Stones. || Theſe were a kind of moveable Pent-houſes or Galleries.
§ Theſe were much the ſame with our Galleries. ⸸ Theſe were for ſcaling of Walls.

nance

nance under the general Title of *Cannon*; but becauſe they vary ſo much from each other in Form, Effect, and Property, as well as in handling; and ſince the particular Conſtruction and Uſe of each of them require a ſelect Treatiſe apart, in order to inculcate a proper Idea of them into the Reader; they ſhall each have a particular Chapter to themſelves in the *Second Part* of our *Artillery*. Now to illuſtrate that the Word *Machine* would be no improper Term for our Uſe, I ſhall firſt recur to the Teſtimony of *Moſes*, where he ſaith, † *Only the trees which thou knoweſt that they be not trees for meat, thou ſhalt deſtroy and cut them down, and thou ſhalt build* Machines *againſt the City that maketh War with Thee until it be ſubdued.* And in the ſecond *Book* of *Chronicles*, where mention is made of King *Uzziah:* ‡ *And he made in* Jeruſalem Machines *invented by cunning Men to be on the Towers and on the Bulwarks, to ſhoot Arrows and great Stones withal.* Again; that *Illuſtrious Prince of Architects* and great *Engineer Vitruvius*, ſtill farther confirms me in what I have been ſaying, by placing *Baliſtæ* (from whence our modern *Cannon* are derived) in the Rank of *Machines*, giving us their Order and Diſtinction to this effect: * *A* Machine *is the Aſſemblage or Conjunction of ſeveral Members, and calculated for removing vaſt and ponderous Bodies; The Motion of which is artificially contrived by the Help of Wheels and other Circular Movements. The* Scanſorium *or Scaling Machine is of one Sort, the* Spiritale *or* Pneumatical *Machine of another, and the* Tractorium *or Draught Machine of a Third Sort. The Scaling Sort is adapted for Perſons to climb up, by means of Croſs Pieces of Wood or Steps, without any danger, and to help in the overlooking of a Place. The* Pneumatical *Sort, by the Inflation of Wind or Air, expreſſes Organnic Sounds*, &c. *And the Draught Sort is for carrying, removing or raiſing up great Weights or Burthens. The Scaling Machines do not ſo much glory in their artful Contrivance, as in the Boldneſs of the Attempt, and are compoſed of Chainings, Tranſums, Bindings, Joints, Buttreſſes and Props. The Wind Machines are capable of very notable Effects. But the* Machinæ Tractoriæ *or Draught Machines, are the moſt Noble of all, as they are more Magnificent, and with a ſhare of Prudence applicable to mighty Uſes: The Action or Motion of ſome of theſe is Mechanical, and of others Organnical. Between* Machines *and* Organs *there ſeems to be this Difference (namely) the Firſt of them require the help of many Hands or additional Strength to aſſiſt them in the performance of their Effects: Such as the* Baliſtæ *and the ſeveral ſorts of* Preſſes. *And the latter on the other hand operate by the ſlight artful* Touch *of a ſingle Perſon, as may be obſerved in the Projections of the* Scorpiones *and* || Aniſocyclæ; *therefore are they both uſeful in different*

† Deuter. XX. In theſe two Scriptural Paſſages our *Engliſh* Verſion uſes the Word *Engine*.
‡ Chr. Book II. Chap. XXVI ver. xv. * Vitruv. Lib. X. Cap. I.
|| This was an Engine compoſed of a great Number of Wheels or Movements.

Reſpects

Reſpects and Occurrences, and without them we ſhould be oftentimes embarraſſed in the carrying on of Works.

From hence there may be thoſe who will object againſt me, and ſay, that our *Cannons, Mortars, Petards, &c.* might be more properly called *Organs* than *Machines*, and that they particularly ought to be called ſo (according to the Definition above from *Vitruvius*) becauſe the greateſt Part of them may be managed and governed by one Perſon. But to this I reply; that the Word *Organ* cannot for that Reaſon obtain with regard to the Greater Pieces, ſuch as ſome of the larger *Cannon* and *Mortars*, which cannot be loaded and played by one Gunner, or laid to paſs by one *Pyroboliſt*; but require the Work of many Hands; add to this, that they not only require to be tended by a Number of Men; but it is alſo neceſſary to have Horſes to move and tranſport them from Place to Place: But I muſt confeſs that Muſquets, Piſtols, and other Portable Arms might not improperly be called *Organs*, as well as the *Scorpiones*, Bows, and Croſs-Bows of the Ancients: However, if this will not ſatisfy you, e'en call them *Machines*, as we have called our *Cannon*, and as the celebrated *Ericius Puteanus* has called them in his little Book of the *Treble-Barrelled Gun* invented by *Mic. Flor. Langrenus*, where he ſaith: *At length, though late, the Firelock, that* Machine *of* Machines, *was invented, and was firſt uſed by the* Danes. (And a little lower) *Now ſince this* Machine *is contrived to carry three* Bullets, *very conveniently and in very little Room, &c.* And a little lower he does not even ſcruple to call Piſtols *Machines*. This anſwers very much to our Purpoſe; but let us reſume our Subject. Comprehending then all the Warlike Inſtruments above recited under the general Denomination of *Machines*, we will under the Title of *Bodies of Fire* take in the ſeveral *Pyrotechnic Tubes* or *Caſes* as well Recreative as Warlike, Cylinders, Stocks, Barrels, Sacks, Baskets, to which we will add Crowns, Garlands, Fire-Hoops, Staves, Cups, and all other Artificial Fire-Works of that Kind. Under the Title of *Miſſiles* (by which are meant *Projectiles)* we will range Fire-Darts, Arrows and Javelins, Fire-Pots and Flasks: Under this Head we might alſo diſpoſe of our Recreative and Military Globes, all which we have amply treated of in the Preceding Books; but each of them being already diſtinguiſhed by particular Appellations, they ſeem to be excluded from this Liſt: And indeed they bear little or no Reſemblance to theſe in Point of Form, though they may with as much Propriety as theſe be ſtyled *Projectiles*, from their being either thrown or ſhot. In fine, under the Title of *Artificial Pyrotechnic Arms* we comprehend Targets, Shields, Swords, Poles, Clubs, and Lances.

And upon the whole, as theſe Things are partly *Recreative* and partly *Warlike*, we will divide this Book into two Parts; the Firſt of which ſhall treat of the *Former*, and the Second ſhall inſtruct you in the *Latter*.

PART

PART I. *of this* BOOK.

Which Treats of

RECREATIVE MACHINES,

Maſſes or *Bodies Fix'd* and *Projectile*, and *Arms Artificial* and *Pyrotechnical.*

CHAP. I.

Of Artificial Shields *and* Bucklers.

SORT I.

TAKE two Fir or Lime-Tree Boards well dried and planed; of the Thickneſs of a Finger or thereabouts; and get them made Round by a Joyner, if you cannot do it yourſelf. They may be 3 Foot in Diameter, but that is left to the Diſcretion of the Workman. Upon each of theſe Round Boards trace out a Spiral Line, beginning from the Center of each of them, and continue it within an Inch of the exterior Circumference of them: The Revolutions of theſe Spirals muſt be Parallel or Æquidiſtant from each other, and their Diſtance may be 3 or 4 Inches or Fingers. Along theſe Lines, you muſt cut out a Groove of equal Breadth and Depth throughout, with an hollow Chiſſel (I ſhewed you ſome ſuch in *Book* III.) or ſome ſuch Tool, ſo that theſe Grooves may either bear the Form of a Concave Semi-Cylinder, or of a Parallelopiped. The hollow Channels or Grooves when they are narroweſt ſhall be always 6 Lines, and when broadeſt one Inch. Theſe Spiral Cavities muſt be wrought upon each Board with ſuch Exactneſs and Nicety, that when you come to join them together the outward Extremities of each may exactly meet and correſpond with one another, in ſuch manner that from their Meeting or Fig. 171.

Termination they may mutually involve together, and form a Spiral Hollow Cylinder; and therefore if you would have them anſwer curiouſly in this particular, you muſt ſo order it that the Spiral Lines you firſt draw upon the aforementioned Boards, may be exactly in the middle of the Channels or Grooves which you cut out, or ſink into them. This done, you ſhall fill the aboveſaid hollow Spiral Cylinder with *Quick Match* looſely twiſted, or with a *ſlow Compoſition* ſprinkled over with a Gum Water, that it may ſtick together and adhere the better; to the end that when you come to join your Boards, the *Compoſition* may not fall out of your Spiral Cavities, and by that means waſte your Time and fruſtrate your Labour. This done, nail them together, and to ſecure them ſtill the better, you may alſo glue them. After this, you ſhall trace out a Spiral Line upon the outward Surface of either of your Boards, (ſo as exactly to correſpond with the interior Spiral) which muſt be bored with ſmall Holes, into which you muſt thruſt the Fuzes of ſuch *Crackers* as I gave you in *Fig.* 108 under the Letter B, which *Crackers* muſt be at the Diſtance of two good Inches from one another, for fear when any one of them in particular goes off and burſts, it ſhould ſome how or other incommode thoſe next to it: And therefore muſt their Fuzes be firmly glued in the Holes they run into, and themſelves be well glued to the Board, and re-inforced with thin Iron Plates on the Outſide, or with good Marline or Packthread to prevent them from flying abroad. To the Inner Side of this *Shield* (by which is meant that Side of it which is next to the Body) you ſhall faſten two Straps or Loops of Leather, or ſomething of that Nature, that you may conveniently handle your *Buckler*. In ſhort, you muſt paſte or glue a ſingle Paper over all theſe *Crackers*, which muſt be done ſo artfully as to ſwell out in a round Knob or Boſs, or elſe project in a Spike or Point towards the Middle, and by means of the Boſs or Spike bear the exact Reſemblance of a real *Warlike Shield*: And in order to diſguiſe the whole the more effectually, you ſhall paint it over of an Iron or Copper Colour. There now remains nothing farther to do in this Caſe, than to bore an Hole whereby to fire it, if ſo it be that your Inward Cavity does not come out to the Edge of the *Shield*. When you would have the Pleaſure of ſeeing the Effects of this, ſet fire to the incloſed Matter without apprehending any Danger, and let the Perſon that holds it ſtand firm at the Exploſion of each of the *Crackers*, and not offer to throw away his Arms till the whole Proceſs of its Operation is compleated. See *Fig.* 171.

SORT II.

Fig. 172. What we have ordered for the preceding Sort as to the Proportions of the Boards, the Form, Size, Spiral Lines and Cavities, the filling of them with *Quick Match*, the Faſtening and Conglutination of the two

Boards, the Straps or Handles, and the Manner of covering the whole, muſt be likewiſe obſerved in the Conſtruction of this: There is only this one Article that conſtitutes a difference between them, (namely) That inſtead of *Paper Crackers* parallel to the Plane of the Surface of the *Shield*, you muſt ſtick in *Running Rockets* or *Iron Crackers* perpendicularly to the ſaid Plane: The Holes for receiving them ſhall be bored cloſe home to the included *Match* or *Compoſition*, and ſhall be of ſuch Breadth as is required by the Size of your *Rockets*, &c. Obſerve here, that your Inner Cavity that holds your *Match*, may be made a little narrower than in the preceding *Shield*; becauſe the Fire purſuing its Courſe in that Spiral Direction, and ſucceſſively preying upon the included Matter, its breathing Holes or Vents are larger, and in greater Number, by its driving out theſe *Rockets* and *Iron Crackers* than before. Letter A points out the Place where you are to prime, and ſet fire to the whole. See *Fig.* 172.

SORT III.

The *Figure* which you ſee in 173, repreſents the Form of an ancient *Eſcutcheon.* This alſo is conſtructed much after the ſame manner with the above *Shields*, it being compoſed of two light Boards: But there is this Difference ſubſiſting between them, that the Interior Cavity of this is not formed in a Serpentine or Spiral Direction, but is only a Complex Line according to the Breadth of the *Eſcutcheon*; I mean, that you muſt draw Parallel and Vertical Lines (at the Diſtance of at moſt a Finger from the Edges of the Boards) which laſt muſt alternately be produced from the Extremity of one Parallel Line to another; ſo that by their mutual Terminations in each other, they may all together form as it were one continued Line, and conſequently that the Cavities hollowed out in that Direction may be one continued Cavity compoſed of ſeveral Branches (ſomething like the Meanders of a River) deſcending from the Top of the *Eſcutcheon* to the Bottom. The Parallel Lines or Cavities ſhall be 2 or 3 Fingers from each other, as we ſaid above. The Holes which you bore for your *Running Rockets* or *Crackers* muſt be in ſuch order as not to be directly under each other, but in ſuch a Poſition as to be Triangular-wiſe, or in ſuch Manner that four of them may include or form a *Rhombus*, compoſed of two ſimilar and equilateral Triangles, by means of which the *Rockets*, &c. will be at a convenient Diſtance from each other. As for any thing farther relating to the *Eſcutcheon*, it is the ſame with what we have above directed. You may contrive to give it an artificial Belly or Swelling in the Middle according to the Bigneſs of it, that it may have the better Appearance, and that riſing out towards the Middle it may have the Shape of a Pan-tile, or ſomething of that kind. Fig. 173.

SORT

SORT IV.

I here preſent you with another *Eſcutcheon* which is of an Oval or Elliptic Form, as you may ſee in *Fig.* 174: The Conſtruction of this is ſomething like that of the preceding; but inſtead of ſingle *Rockets* or *Crackers*, you muſt have little Wooden Boxes, or Paper Caſes, or *Cartouches* as A, filled with *Running Rockets*, which ſhall be alternately diſpoſed as in the laſt Sort, (*viz.*) Triangularly or Rhombuſidical. Your Cavities aforementioned muſt be in Proportion to the Length and Breadth of the *Eſcutcheon*, and the Parallels may be joined as in the laſt Sort by Vertical or Tranſverſal Lines or Cavities, which ſhall turn to and exactly humour the Sweep or Form of the *Eſcutcheon*, as in the foregoing Sort. Upon the whole, you may (if you pleaſe) make your Inner Cavity in a Spiral Direction, exactly anſwering to the Form of the *Eſcutcheon*, and then diſpoſe of your Boxes or Caſes juſt as you did with the *Rockets* and *Crackers* in the firſt and ſecond Sort: However, you muſt take care that the Revolutions of your Spiral Cavities (and the ſame thing muſt be obſerved, if your Cavity is wrought in a Rectilinear Direction) are at a much greater Diſtance from each other than in the former *Figure*, and that, in Proportion to the Size of your Caſes, which upon the ſcore of their Largeneſs ought to be at a greater Diſtance from each other than the ſingle *Rockets* and *Crackers* that do not produce ſo great a Fire. If the aboveſaid Caſes are made of Wood, they ſhall have their Bottoms bored with a ſmall Hole, into which you muſt thruſt one End of a little Fuze (made of Copper or Iron) filled with *Meal Powder*, which muſt be driven very hard in it; the other End of each of theſe Fuzes ſhall go into the Board which forms one Side of your *Eſcutcheon*, and muſt bear upon the Combuſtible Matter contained within it through ſmall Holes made to receive them; and by them the Fire will be conveyed to your Caſes of *Rockets*, and cauſe them to depart. If your Caſes are made of Paper, you may leave them open at Bottom, and let them into the Outward Surface of your *Eſcutcheon* to the Depth of two or three Lines, and ſecure them faſt with Glue, having firſt bored little Holes through the Board aforeſaid, (which muſt be filled with *Meal Powder)* which muſt be exactly under the Middle of the Caſes. This done, you ſhall head up all your Caſes with Cornets or Paper Cones, if ſo it be that the outward Surface of your *Eſcutcheon* is to be flat and bare, but if it is to be ſomewhat raiſed or ſwelled in the Middle (which may be eaſily done by a Covering of Paper or Cloth) their Heads ſhall be flat. Any thing farther relating to this, may be gathered from what has been ſaid of the preceeding Sorts of theſe *Shields*.

Fig. 174.

SORT

Sort V.

The laſt Sort of *Buckler*, which you ſee in *Fig.* 175, cannot be performed till you have a previous Knowledge of the Conſtruction of *Fire-Wheels*: I ſhall therefore reſerve what I have to ſay of it till I have treated of *Wheels*: I ſhall only here inform you, that this *Eſcutcheon* may be of what Form or Figure you pleaſe, and that it muſt be made but of one ſingle ſolid Board, and that the Surface of it may be flat, or ſwelled out in a Boſs in the Middle of it; and finally, that the *Fire-Wheel* muſt be fixed exactly in the Middle of the *Eſcutcheon* or *Buckler*, upon a ſmall Axle or a round Pin firmly driven into the Wood, that it may turn round the more freely. Every thing farther concerning this *Machine* will be taught by the Sequel. Fig. 175.

Chap. II.

Of Fire-Cutlasses.

Make a *Cutlaſs* of two Pieces of ſmooth dry Wood, after the Faſhion of a *Poliſh Sabre* or *Turkiſh Scymitar*, with a crooked Back and only one Edge, as may be ſeen in *Fig.* 176: Put the Edges of your two Boards together, and keep the Back open to the Breadth of two or three Fingers, ſo that between them there may be a Hollow, whoſe Profil or tranſverſal Section anſwers to an *Iſoſceles* Triangle. Divide the whole Length of this Cavity by little Triangular Partitions of Wood, exactly fitting the Form of the ſaid Cavity, and glue them well to the Innerſides of your *Cutlaſs*, and to faſten them ſtill the better drive little Wooden Pegs into them from the Outſide, or elſe little Brads. You ſhall then add a Gripe or Handle to it, that it may be conveniently handled and managed. But before you faſten in your little Partitions, it will be proper for you to make a little Groove or Channel within-ſide, right over the Conjunction of the two Edges of your Boards, into which you muſt put *Slow Compoſition* to the Height of half a Finger, or elſe you may lay *Quick Match* in it, and cover it with a thin Sheet of Lead, or with a thin Slip of Board, over which you muſt glue or paſte a Piece of Paper, to keep it down upon your Priming. You muſt not forget to bore little Holes through which your *Compoſition* or *Match* may correſpond with each of your Partitions, and accordingly fire the *Running Rockets* (or *Squibs*) *Stars*, *Sparks*, *Light-Balls*, or other ſuch like Things wherewith thoſe Partitions are uſually filled up. In ſhort, after having paſted a ſtrong Paper over the Back of your *Cutlaſs*, you ſhall coat it all Fig. 176.

round with a Cloth, and paint the Blade of it in Imitation of Iron. If you would have any additional Pleaſure from this *Machine*, you may on each Side of the Blade ſtick *Crackers* in *Saltier*; that is, in Form of St. *Andrew*'s Croſs, as may be obſerved in the *Figure*. The Touch-hole where you are to fire your *Compoſition* or *Match*, muſt be near the Point of your *Cutlaſs*.

CHAP. III.

Of an Artificial ‡ Hanger *or* Dagger.

Fig. 177. THE Form of the *Hanger* which you have in *Fig.* 177, is not very different from that of the *Cutlaſs* I juſt now deſcribed: This like the former is made of light dry Boards. The Edge of it is hollowed in the Form of a Concave Semi-Cylinder; in which you are to fix *Rockets* of 8 or 10 *Ounces*, more or leſs in Proportion to your *Hanger*, and in Proportion to the hollow Edge of it: You ſhall fill them with one of the *Slow Compoſitions* I have already given; but for want of them, the following *Compoſition* will do very well. Take of *Powder* 5 Parts; of *Saltpeter* 3 Parts; of *Coal* 2 Parts, and of *Sulphur* one Part; beat, mix, and incorporate them well together, and fill up your *Rockets* with it to the Brim, without capping them or adding any Report to them as is commonly done for *Rockets*; in ſhort, without heading up or boring them at all, lay them open one upon another in the hollow Edge of your *Hanger*, and gluing them well on, cover them over with Paper. Farthermore, you may on each Side and on the Back of the Blade ſtick *Paper Crackers*, in ſuch a manner as not to be ſhaken or torn off: To conclude, each of your *Crackers* ſhall correſpond with the *Rockets* by little Fuzes filled with *Meal Powder*, through which the Fire may be conveyed to them from the *Rockets*.

CHAP. IV.

Of ARTIFICIAL SWORDS.

IT is waſting of Time to beſtow more of it upon the Performance of any Thing than the Nature of it requires; a due Regard to which Maxim ſhall be had in this *Chapter*; for in truth, the Figure of the

‡ The *French* calls this *Demy-Eſpadon*.

Fire-

Fire-Sword which you have in Number 178, needs not the leaſt Explanation; for it differs in nothing but in Form from the *Artificial Hanger* above deſcribed: Therefore to avoid an impertinent Repetition of what has already been ſaid, and the Trouble of inventing new Terms; I ſhall tell you in few and plain Words, that the Conſtruction of the *Fire-Sword* does not vary a Nail's-breath from the Conſtruction of the *Hanger* above. Fig. 178.

CHAP. V.

Of FIRE-POLES *or* RODS.

YOUR *Fire-Poles* ſhall be of the Length of 10 or 12 Foot, and of the Thickneſs of 2 Inches at moſt. You muſt hollow one of the Ends of it with 3 or 4 Flutes to the Length of 2 or 3 Foot. Into one of theſe Flutes you muſt fix *Rockets* or *Squibs* prepared after the manner we ordered above; but in the others, you muſt fix *Paper Crackers* only; after having bored Holes through the Body of the Pole through which the *Rockets* may have Communication with the *Crackers*: Wrap them then neatly in Paper, the more effectually to deceive the Spectators. See *Fig.* 179. Fig. 179.

CHAP. VI.

Of FIRE-WHEELS.

SORT I.

THE moſt common and ſimple Sort of *Fire-Wheels* is that which you ſee repreſented upon our *Shield* or *Eſcutcheon* in *Fig.* 175. It is made of light Fir or Lime-Tree Boards well jointed together, and wrought in an Octangular Form. In the Center of it is a little Nave into which the Spokes of the Wheel are fixed, which ſupport the Fells. The Eight Sides of this are fluted or hollowed juſt as we have ordered for the *Hangers* and *Poles*; into which Flutes or Grooves you glue large *Rockets* (namely) one, two, or more, according to the Dimenſions of your *Wheel*. But it is in this Caſe neceſſary that your *Rockets* ſhould be bored juſt like *Sky-Rockets*, and filled with the uſual *Rocket Compoſition*; they ſhall likewiſe be choaked at Top, ſaving only a moderate Hole in the Head of each, by which the Fire when it has conſumed Fig. 175.

one

one of them may paſs to the next to it, and ſo on till they are all burned out ſucceſſively one after another; but the Head of the laſt muſt be carefully ſtopped or cloſed up, and you muſt ſome how or other contrive that it be not in danger of being accended nor incommoded by the redundant Fire iſſuing from the firſt. To conclude, you may to this laſt *Rocket* add a Report of *Corn Powder*.

SORT II.

Fig. 180. This *Wheel* is a little more Artificially contrived than the foregoing. As to the Form of it, it is perfectly round, and has a Flute or Groove all round the Convexity of it, into which are fixed ſuch *Rockets* as we ordered above: On each ſide of the Fells (as they are commonly called) you muſt firmly fix *Paper Crackers*, which ſhall correſpond with the *Rockets* by little Fuzes filled with *Meal Powder*. *Fig.* 180 will give you a compleat Idea of every thing elſe relating to it.

SORTS III and IV.

Fig. 181. The Conſtruction of the *Wheel* I am now going to give you is much the ſame with that of the Firſt Sort, and in point of Form is exactly like it. But this exceeds the foregoing two, inaſmuch as it has two Rows or Revolutions of *Rockets*, in conſequence of which it has two contrary Rotations (namely) to the Right and the Left, or Forwards and Backwards. But you may imagine that theſe Rotations are not performed at the ſame time; but whirling round in one particular Direction till the lower Range of *Rockets* is ſpent, it turns back again by a Retrograde Rotation when the upper *Rockets* are fired, by means of a private Fuze. Caſt your Eye upon *Fig.* 181, where you will ſee how all this muſt be ordered.

Obſerve here that all the *Rockets* (or *Wheels)* we have here mention'd muſt be either in a Horizontal or a Vertical Poſition; that is, whilſt they are burning, they muſt turn upon an Iron Axle (ſuch as you ſee in Fig. 182. *Fig.* 182) either parallel to the Plane of the Horizon, or perpendicular Fig. 204. to it. Under *Fig.* 204, I have repreſented an *Horizontal Wheel* diſtinguiſhed by the Letter E, and cloſe by it a *Vertical* one in the Letter G. Remember here that this *Horizontal Wheel* holds the Fourth Place of *Fire-Wheels*; becauſe it is in ſome ſort different from the reſt; its ſuperior Plane being all ſtuck full of *Running Rockets* (or they may be *Sky Rockets* if your *Wheel* is big enough;) add to which, that the Conſtruction of it approaches pretty near to that of the *Shield* or *Buckler* of the Second Sort, with regard to the *Rockets* that are ſtuck into it: As to any thing farther concerning this *Wheel*, you may gather it from what has been ſaid of the preceding Sorts.

Beſides

Fig. N.° 152.

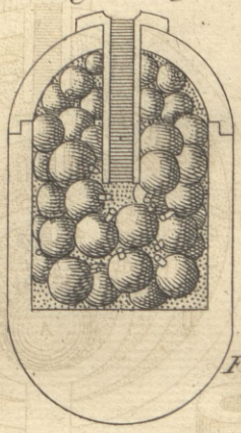


Fig. N.° 153.

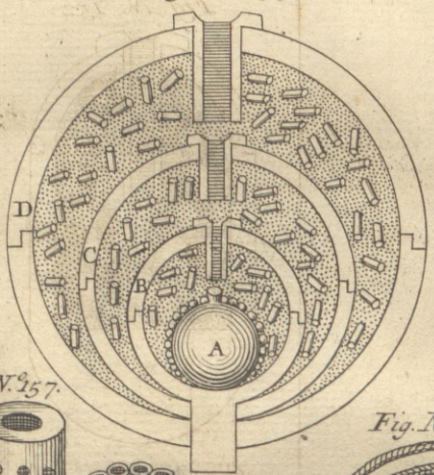


Fig. N.° 154.

Fig. N.° 155.

Fig. N.° 157.

Fig. N.° 158.

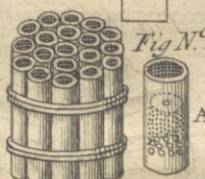


Fig. N.° 159.

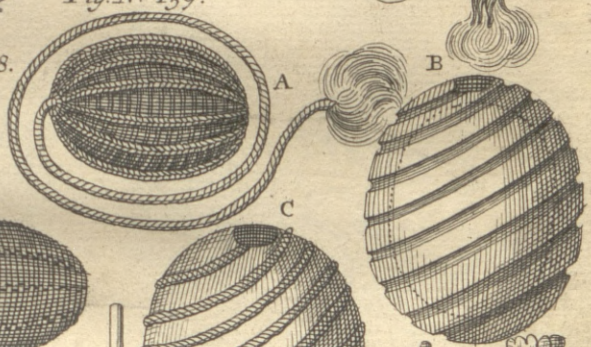
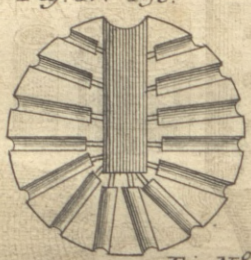


Fig. N.° 156.



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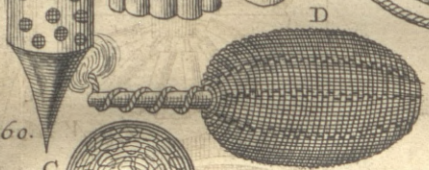
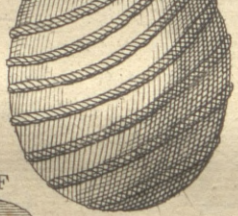
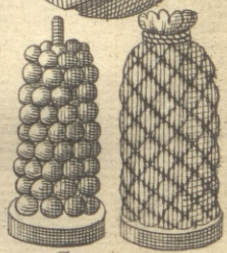


Fig. N.° 161.





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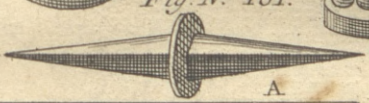

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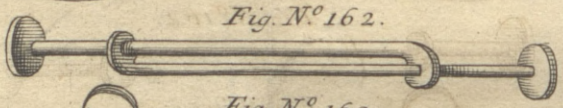


Fig. N.° 163.

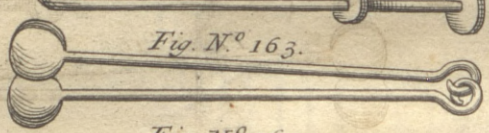
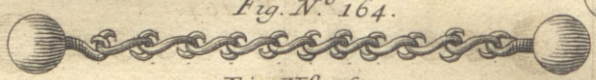


Fig. N.° 167.

Fig. N.° 164.



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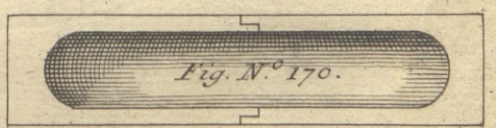


Fig. N.° 171.

Fig. N.° 172.

Fig. N.° 168.

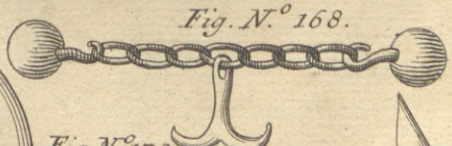


Fig. N.° 173.

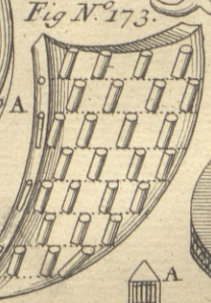


Fig. N.° 169.

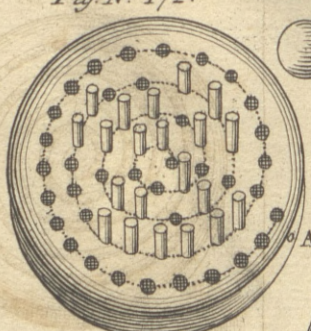


Fig. N.° 176.

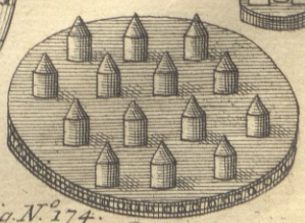


Fig. N.° 174.

O

P. F. Sculp.

Beſides this; I here give you a round *Wheel*, of which is formed a Baſon of a Fire Fountain. This you have in *Fig.* 202, diſtinguiſhed Fig. 202. by the Letter B. The Plane of it is pointed out by E, but the true Orthography of it, and the manner how it is to be contrived ſo as to turn round upon a Tube or Caſe of *Compoſition* may be ſeen in F. But let us go on, for we ſhall have occaſion to ſpeak more particularly of this in the Sequel.

SORT V.

In order to conſtruct this Fifth Sort of *Wheel*, you muſt firſt have a Fig. 183. pretty large Wooden Bowl or Diſh, with a broad flat Brim, ſuch as you ſee in *Fig.* 183, under the Letter B. Then you muſt have a light, dry, ſquare Board, of 2 or 3 Foot in Breadth each way. Saw off the Corners of this Board and convert it into an Octangular Table, and cut out a round Groove (or as the Original has it *Semi-cylindric)* all round the Thickneſs of it. This done; cut out a large round Hole in the middle of this Octangular Board, in which you muſt fix a Water-Globe, or ſomething of that kind, or ſuch as thoſe we gave you in the Third Sort of *Running* or *Leaping Globes*; but be the *Ball* what it will, you muſt ſo order it that one of its Hemiſpheres may be hid and received in your Wooden Bowl, and the other riſe up above your Octangular Board: Nail down this Board upon the broad Brim of your Bowl or Diſh, and fix your Globe in the middle of it, as we ſaid above, and tye it down faſt with Wyre, or ſecure it by any other Contrivance ſo as to prevent its eſcaping out of the Bowl. This done; glue ſuch *Rockets* as we ſaid above in the Groove that runs round the Thickneſs of your Board, laying them cloſe after one another, ſo that ſucceſſively taking Fire from one another, they may keep (as long as they laſt) whirling the *Wheel* with one uniform Rotation. If you will you may add on each ſide of the *Wheel* three or four ſuch Boxes or Caſes as we mentioned above, which muſt be erected perpendicularly to the Plane of your Octangular Board: To conclude, you may upon the ſame Board or Plane range a Number of *Crackers* lengthways following one another; of theſe you may not only have one Tire or Range, but two or three Tires one within another, juſt as you fancy, and as the Extent of your *Wheel* (as we have called it) will permit.

Your private Trains or Fuzes ſhall obſerve the following Order; firſt conduct one to the *Rocket* which is to take Fire the firſt from the Globe fixed in the middle, whoſe Side muſt be pierced cloſe home to the *Compoſition* it contains; let this Train be of *Meal Powder* and cloſely covered up. You muſt then have Trains or Fuzes of Communication from the *Rockets* to each Box or Caſe, and from them to each *Cracker*, and from the outward Ranges or Tires of *Crackers* to the Inner, if ſo it be that you have more than one. All theſe Trains muſt be of *Meal Powder*.

The Boxes or Caſes muſt be ordered and fixed, as we directed in our Fourth Sort of *Shields*. Finally, the whole as compounded of all its Parts ſhall be univerſally coated with Pitch, ſo that your *Wheel* being committed to the Water, that Element may not have the leaſt Admittance into your *Trains*, *Rockets*, *Caſes* and *Crackers*, nor into your Bowl or Diſh; for except it be very ſubſtantially coated over, your Labour will vaniſh in Smoke, or (to ſpeak more proper in the preſent caſe) turn into Water, and balk you of the Diverſion you expected. In doing this then, the *Pyroboliſt* will have an Opportunity of diſplaying his Induſtry and Skill.

Obſerve here this Firework muſt be enkindled in the Middle of it, and as ſoon as your *Compoſition* is thoroughly fired you muſt eaſe it gently down into the Water. Caſt your Eye upon the *Fig.* where you will ſee a Curious Repreſentation of every thing we have here deſcribed, diſtinguiſhed by the Letter A.

Fig. 183.

CHAP VII.

Of Artificial Clubs *or* Maces.

SORTS I and II.

I Shall not here take up your Time with a particular detail of the ſeveral Sorts of *Clubs* which *Pyroboliſts* have been pleaſed to invent and deſcribe; for (as I have already ſaid) I do not propoſe to dwell upon any thing that is trivial, nor to ſweep out our *Pyrotechnic Granary* to the minuteſt Straw, but only by an aſſiduous Labour and Induſtry to pick out the choiceſt Grains of our *Pyrotechnic* Stores for you: And therefore I ſhall only preſent you with the three following Sorts. The two firſt of which *Fig.* (184 and 185) are perfectly like the *Water Globes* of the Seventh and Ninth Sort, and therefore I ſhall refer you to them for the Conſtruction of theſe. You need only add handſome turned Handles to them, ſuch as you ſee repreſented in the Figures themſelves, or any other that our *Pyroboliſt* ſhall like better. To this I ſhall ſubjoin a *Compoſition* that I take to be more proper and convenient for theſe than what is uſually made for *Water Globes*. Take of *Pitch* 1 ℔; of *Sulphur* ℥iiij; and of *Coal* ℥ij; beat, mix and incorporate them well together, and ſprinkle them over with any fat, oily Subſtance or with Brandy, and charge your *Balls* with this Mixture: Or if you pleaſe to make uſe of the *Compoſition* we ordered above for the *Cutlaſs* it will do very well and is very fit for this purpoſe.

Fig. 184. and 185.

SORT

SORT III.

Get a *Club* turned with its Handle and a Spheroidical Head, and let it have a Spheroidical Cavity withinside; but this Cavity must be so contrived that the Solid Substance of the Wood or Shell be throughout of the Thickness of five Inches at least: Or else it may be bored with a round Hole from the Top to the Middle of it, of the Breadth of 3 or 4 Inches. Farthermore, you must bore the Sides of it all round with Holes of the Diameter of 3 or 4 Inches, and to a Depth answering to the Length of a *Running Rocket*, all which Borings must tend to the Cavity in the Middle. Fig. 186.

You must then bore fine Holes branching from the Bottoms of these great Cavities, to that in the Middle, in which they must all terminate; and these shall be filled with *Meal Powder*. This done, make Paper Cases upon a Rowler, which must be a little less in Diameter than the Cavities abovementioned; these Cases shall be neatly pasted together, so as to slip easily into the Cavities they are to be fixed in; and if you will, you may make Paper Bottoms to them, provided that those Bottoms are pierced in the Middle to give the Fire Conveyance to the *Rockets* which are confined within them: Having fixed them in the Holes of the Head of your Club, you must cover each of them up with a Paper Cone, after having capped all your Cases with a round piece of Paper, to keep them from falling out of their Holes: You may fill the middlemost Cavity of your Club with the *Composition* we just now gave for the two foregoing Sorts; or you may use the following, which is much of the same Nature. Take of *Saltpeter* one ℔; of *Sulphur* ℔ ſs; of *Powder* ℥ iiij; of *Coal* ℥ ij. Finally, dip the whole Body of your *Club*, armed as it is with its pointed or conic Heads, into a good Quantity of melted Pitch, or coat it over with Glue; in a Word, paint it over of what Colour you please. See *Fig.* 186.

CHAP. VIII.

Of the FIRE-STAFF *or* STICK.

THE *Fire-Staff* may sometimes supply the want of an *Artificial Wheel*, inasmuch as it is contrived to turn and whirl round upon an Iron Nail or Axle, which is an Action common to *Fire-Wheels*: As to the Construction of it, it is neither very costly nor troublesome: You are to fill two *Sky-Rockets* of what Size you will with a sutable *Composition* up to the Brim; and bore them to ⅓ of their Height with a proper Fig. 187.

Borer

Borer or Taper-bit. Then get a ſolid Wooden Ball turned with two Arms or little Axles Diametrically oppoſite to each other, and exactly fitted to the Orifices of the *Rockets* into which they are to be ſtuck. Bore then an Hole through the Body of your Ball, interſecting the Imaginary Line which paſſes through the Center of the Arms or Axles of your Ball at right Angles: To the Outſide of theſe two *Rockets* you may fix *Crackers* all on the ſame Side; but their little Fuzes muſt be 2 or 3 Fingers from the Orifices or Heads of the ſaid *Rockets*. On the Side oppoſite to theſe *Crackers* there muſt run a long Tube or Fuze, through which the Fire may be conveyed from the firſt *Rocket* that burns out to the Choak of the other; which ſhall be covered with a little Paper Cap, as we ordered formerly with regard to *Rockets* that run upon Lines. In the Profil (*Fig.* 187.) you ſee the Wooden Ball with its two Axles diſtinguiſhed by the Letter A, as ſtuck into the Orifices of the *Rockets*; B and C are the two *Rockets* as filled with *Compoſition*, and bored as they ought to be. E and F are the Paper Crackers. D the Tube or Fuze; the reſt may be learned from the *Figure* itſelf.

CHAP. IX.

Of the FIRE-CUP.

Fig. 188. ORDER a *Cup* or *Goblet* to be made of Wood or Metal, after the Faſhion of any Drinking-Cup that you like beſt; as for me, I find none better adapted to this Purpoſe, than that which you ſee repreſented in *Fig.* 188: The Lower Part or Leg of it muſt be bored from the Foot up to its Concavity, into which Boring you ſhall thruſt a Wooden or Metal Fuze filled with the following *Compoſition*, which will yield a very black obſcure Fire. Take of *Pitch* ℥ iiij; of *Sulphur* ℥ ij; of *Coal* ℥ j; of *Crude Antimony* ℥ ij; and of common *Salt* ℥ j.

Fill the Capacity of your *Cup* with *Running Rockets* (or *Squibs*) after having ſalted the Bottom of it over with a Mixture of *Meal* and *Corn Powder* to make them fly out. Shut them in, and cover them with a round Board of the Thickneſs of 3 or 4 Lines, and that, to ſuch a Nicety that the lower Surface of it may bear upon the Heads of the *Rockets*, and its Circumference exactly correſpond with the Concavity of the *Cup*. Then pitch the remaining Cavity of your *Cup* up to the Brim, and cover the round Board upon the *Rockets* with a tarred Cloth, to keep it tight, and to prevent any of the Pitch from running in among the *Rockets*.

The ingenious *Pyroboliſt* may apply this *Cup* to a thouſand artful Uſes; particularly in drinking to the Health of ſome Perſon of Diſtinction.

ction. He need only firſt fire the Fuze or Caſe that runs down to the Center of the Foot of this Goblet, and whilſt that is burning, toſs off at once what Liquor is in it, and immediately lifting it above his Head, keep it in that Situation till the *Rockets* are fired and flown out of the *Cup:* But I muſt here tell you, it is proper that you ſhould have no more Wine in it than may be drank off at one or two Gulps; or elſe it may be neceſſary for the Drinker to have a Throat formed after the *German* Faſhion (I ask Pardon) I mean the *Grecian*; to ſwallow it down at once, if there be a good Quantity of it; for in this Caſe you not only run the Hazard of burning your Noſe, but alſo of ſpoiling your whole Face. Now beſides the *Cup* I have here given you, you may conſult *Fig.* 200 and 201, where you will find others.

CHAP. X.

Of Artificial Caſes *or* Tubes.

OF all the *Pyrotechnical* Inventions that have been brought to light, there are none ſo important or neceſſary in the Conſtruction of *Artificial Pyrotechnical Machines* (which we ſhall treat of in the ſubſequent *Chapter)* as theſe *Caſes* or *Tubes*; for I believe it is impoſſible to think of any Contrivance, that would be more proper to fill up, ſupport, and bear a whole *Machine*, or to throw out ſuch a Diverſity and Redundancy of Fires, in what Order and Succeſſion the *Pyroboliſt* thinks fit to preſcribe, than theſe Caſes, which are uſed in *Pyrotechnics:* And therefore I ſhall here preſent you with ſome of thoſe Sorts which are in the greateſt Requeſt among *Fire-Engineers*; and that, in the moſt regular and conſpicuous Order I am able. To begin,

SORT I.

In *Fig.* 189 you have the Conſtruction of a *Caſe* compoſed of ſeveral Fig. 189.
Pieces or Boxes, whoſe Height is arbitrary, and may be as you pleaſe. Now all theſe Boxes have hollow Bottoms adapted to receive and cover the Boxes which are immediately under them. If theſe Pieces are made of Wood they muſt ſo exactly fit, and receive each other, that it may be difficult to diſtinguiſh the whole from one continued Piece: If on the other hand they are made of Paper (which I like beſt both on the ſcore of their Strength and Lightneſs) you muſt, in Conſideration that they are all of one Size, paſte on a Foot or Bottom of about a Palm in Height to each of them, the Interior Circumference or Concavity of which Bottoms muſt exactly fit and correſpond with the Con-

vexity of the *Boxes* or *Cartouches* themſelves: In ſhort, they muſt be ſo contrived as to ſlip into and fit each other.

I know of nothing more convenient for the Conſtruction of theſe *Boxes* than the Engine diſtinguiſhed by the Letter A, and the two Cylindrical *Formers* by B and C, upon which (having previouſly greaſed them over with Soap) you faſhion your *Boxes* juſt as you think proper, by paſting one Revolution of Paper upon another, turning round your *Former* which has an Axis at each End, ſuſpended upon two Crutches; and having an Handle at one End to turn them round with. Being thus formed, put them to dry by a moderate Heat; for if you dry them ſuddenly by a briſk Fire, they will ſhrivel up: And therefore as ſoon as they are taken off from the *Former*, you immediately clap round Wooden Boards into them to ſerve for Bottoms, which are ſubſtantially glewed into them, and afterwards nailed in from the Outſide to fix them in ſtill the more firmly. The Wooden Fuze belonging to the Bottom of each Box muſt be ordered and filled juſt after the ſame manner as we directed above for the fourth Sort of *Water-Globes*; and the *Rockets* ſhall be fixed after the ſame Faſhion. Now, if you are deſirous of ſeeing how all theſe *Caſes* are adjuſted and fixed in *Pyrotechnical Machines*, caſt your Eye upon the *Statue of Fortune* which we have repreſented in *Fig.* 202, where you will ſee one of theſe diſtinguiſhed at large by the Letter A.

SORT II.

In the preceding Sort, I have given you a *Caſe* compoſed of ſeveral Pieces, which are deſtroyed and blown up by Degrees, as faſt as the *Rockets* contained in one of them can force away the empty Box ſuperincumbent upon them, which has already diſcharged its Load; but I here preſent you with ſome that are ſolid, and which always ſtand poſſeſs'd of their full Height; and only bear *Artificial Fire-works* on their Outſides, which being ranged in a continued regular Order from the Top to the Bottom, burn and fly up into the Air to the Aſtoniſhment of the Beholders: Or they contain *Artificial Recreative Globes*, and ſeveral ſuch like Things which mount upwards to perform their Effects, and leave the *Caſe* empty: All theſe I ſhall entertain you with in the moſt perſpicuous and conciſe Method I am able: Firſt then.

Fig. 190. The *Caſe* or *Tube* which you ſee in *Fig.* 190, muſt be made of ſolid, hard, dry Wood, of what Height and Thickneſs you ſhall think proper. You muſt bore it with a large Augre to the Breadth of a Third or at leaſt ¼ of the Solidity of the Wood. You muſt then divide the whole Height of it into certain equal Parts, which ſhall exactly correſpond with the Height of the *Sky-Rockets* you intend to fix upon it, or they may be a little ſhorter. All theſe Parts ſhall be cut ſloping in downwards, excepting only the uppermoſt which muſt be a Cylinder,

but

but all the reſt ſhall be Portions of a Cone reverſed, ſo that the whole may be divided as it were into Joints like a Cane, and each Joint have a pretty broad Shoulder. Theſe Shoulderings muſt be flat, and have a Groove cut into them, and running all round them, which muſt be of a Finger's Breadth, and of the Depth of 6 Lines, or thereabouts. From theſe Grooves you muſt bore ſmall Holes, by which the Fire may be conveyed to the Trains in them from the Body of the *Caſe*, to light the *Rockets* which ſtand upon them in Paper Cartouches, which muſt be ſecurely fixed to the Wood to prevent them from flying away with the *Rockets*. As to the Conſtruction in general of this, I ſhall refer you to our Chapter of *Water-Globes*, where you will find ſomething of this nature in *Fig.* 101: But the Figure I have given of this, will ſufficiently inform you of every thing relating to it, where A and B denote the Joints of this *Caſe* or *Tube* with their *Rockets*; C the great and ſmall Cavities for your Trains; and D the Orifice of the Cavity in the Body of it. Your Trains in general muſt be of fine *Meal Powder*. But the great Boring which runs down the Middle of the whole (as well as of the reſt which we ſhall deſcribe hereafter) ſhall be filled with one of the *Compoſitions* we gave for *Water-Globes* or *Fire-Balls*: But I muſt caution you to put in about half a Pound of *Corn Powder* after every 5 or 6 lb of *Compoſition*, in order to clear and ſcower the Inſide of the *Caſe* from the Soot, *&c.* which will ſtick to it, and ſuppreſs the Flame, and impede its lively Aſcent. The Bottom of this Tube ſhall be ſolid and ſubſtantial; that is, you muſt not bore it quite through, but leave 3 or 4 Inches of ſolid Bottom to it.

SORT III.

The Form of this *Caſe* in *Figure* 191, ſeems to differ pretty much from the preceding; becauſe this appears to be a perfectly round and uniform Cylinder; though in the main it is hollowed, and cut out in the ſame manner as that above. You are to trace out a Spiral Line from one End to the other of its Convexity; upon which Line you (at a convenient and equal Diſtance) are to cut out Morteſſes or Holes to the Depth of two or three Inches, whoſe Baſes and Perpendiculars fall obliquely upon the Axis and its Parallels: (See Letters B and C upon the ſame *Figure*;) Into theſe Morteſſes you muſt contrive to fix Paper Caſes with Wooden Bottoms, into which you may put any Sort of *Rockets* you pleaſe, as you ſee in A and E. But you muſt take care to have Fuzes or little Holes branching out from the Body of your great Tube to the *Corn Powder* beneath your *Rockets*. Fig. 191.

SORT

SORT IV.

Fig. 192. I can hardly add any thing farther of this to what I have already ſaid above; for this *Caſe* is Couſin-German to the preceding one. However, there is this Difference between them; that the firſt is armed with *Rockets* which fly out of certain *Paper Caſes*; and on the contrary, this is ſurrounded with a Number of *Boxes* or *Cartouches* diſpoſed in a Serpentine Order, like the firſt: Add to which, that they are ſecured as faſt and firmly as poſſible by being glewed, nailed, *&c.* upon the Convexity of the great *Tube* or *Caſe*, and vomit forth a great Number of *Running Rockets* (or *Squibs)*; and in a Word, their Poſition is Right and Parallel to the Axis and Sides of the Tube they belong to. As to any thing farther; this can boaſt of nothing that it has not in common with the other.

SORT V.

Fig. 193. Divide the Periphery or Circumference of a Cylinder at each End into a certain Number of equal Parts, and then produce Subtenſes or Chords ſucceſſively terminating in your Points of Diviſion. By this means you will have two Multi-Angular *Figures* (viz.) one at each End, whoſe Angles and Sides are mutually Similar and Equal. Thus taking the Sides of theſe *Polygons* for your Guides and Directors, cut away the Convexity of your Cylinder and convert it into a *Polyhedronic Priſm:* If you have not a clear Idea of this, caſt your Eye upon *Fig.* 193.

This done, bore it through the Middle with a large Augre, as we directed for the reſt; and bore each *Hedron* or Side of it with a Number of Holes all falling obliquely, or at acute Angles, upon the Axis of the *Priſm*, and the Plane of its Sides; all which muſt penetrate to the great Boring in the Middle. Into theſe Holes you muſt thruſt *Iron Crackers*, or *Running* or *Sky Rockets*, if your Tube is in Proportion to them or can bear them.

The Tower which you ſee in the Middle of our Citadel fortified with 5 Baſtions is built upon a Tube of this Kind, as may be perceived in *Fig.* 204. But the Ingenious *Pyroboliſt* may apply this to ſeveral other Uſes, whether *Recreative* or *Warlike*: For my Part, I ſhall ſpeak no farther of it, but proceed to give you an Account of others which I like full as well.

SORT VI.

If you pleaſe to recollect; you may remember that I diſcourſed pretty largely upon a Tube of this Kind in *Book* III, when I deſcribed to you the Third Sort of *Sky Rockets*, and alſo in *Book* IV, when I treated

ed of the Twelfth Sort of *Water Globes:* So that notwithſtanding I promiſed you then to amplify upon this in another Place, I find the Difference between thoſe which I formerly deſcribed, and that which I have now taken in Hand, to be ſo very inconſiderable, that I can hardly diſtinguiſh one from the other, except it be with regard to Size, and therefore I ſhall refer you to what I formerly ſaid to inform yourſelf in the Conſtruction of this: However I muſt obſerve to you by the way, That all Sorts of Caſes or Tubes (excepting that which we deſcribed Firſt) may be filled after the ſame manner as what you ſee in *Fig.* 194. Where A points out *Pyrotechnic Stars* and *Sparks* interſperſed with *Corn Powder.* B a *Recreative Globe* filled with *Paper* or *Iron Crackers.* C a *Light Ball*, or *Water Globe*, which of them you pleaſe. Finally, D ſhews you another *Recreative Ball* filled with *Running Rockets.* The Hollows and Interſtices between theſe Fires are filled with a *Slow Compoſition* or *Corn Powder* to blow out the *Globes* &c. one after another.

SORT VII.

Truly, I find nothing more troubleſome, nor would there be any thing more unprofitable than to coin new Words to deſcribe each of theſe *Tubes*, ſince by the Conſtruction of any one of them you may with a little Thought get the Knowledge of all the reſt: Add to which, that the *Figures* I have here given you of them, illuſtrate them ſo evidently and plainly, that it is impoſſible for you to commit any Miſtakes if you duly conſider them. And therefore I ſhall add but two or three Words in favour of this Sort. Namely, that you are to fix all your *Crackers* upon the Convexity of it in a Spiral Line, whoſe Revolutions are pretty cloſe to one another, and that they muſt be diſpoſed in ſuch Sort, that they may anſwer to the Form of a *Rhombus* compoſed of two Equilateral Triangles; or elſe Saltier-wiſe, or in Form of St. *Andrew*'s Croſs. Conſider a little on what has elſewhere been ſaid, and caſt your Eye upon *Fig.* 195. Fig. 195.

SORT VIII.

Take a Wooden Cylinder ſmoothly turned, or let it at leaſt be cut out in a roundiſh Form, and let its two Baſes or Ends be equal. Its Diameter or Thickneſs muſt be left to your own Fancy, but its Height or Length ſhall be always ſix times or ten times its Breadth or Thickneſs. This done; flute it as you ſee in *Fig.* 196. Now leſt you might not know how this is to be done, I ſhall diſplay it to you in few Words. Fig. 196.

Divide the Periphery of the Baſe into 6 equal Parts, which you may do by taking the Semi-diameter of the Cylinder: Subdivide then each Sixth into 7 other equal Parts, and take one of theſe laſt Parts for the Liſt or Interſpace between the Flutes or Channels, and the 6 others

ſhall be left for the Channels betwixt the Liſts. They are formed thus.

Take the half Breadth of each Hollow or Flute for a Semi-Diameter or *Radius*, and deſcribe a Semi-Circle from a Point in the Periphery of your Baſe. Then skipping over $\frac{1}{7}$ for an Interſpace or Liſt, deſcribe another Semi-Circle from the Periphery in the ſame manner, and ſo proceed till you have deſcribed 6 Arches. The ſame thing muſt be done at the other End or Baſe. In ſhort, having produced Right Lines from one End to the other of your Cylinder terminating the Breadths of your Interſpaces or Liſts, and your Flutes or Channels; hollow them in Proportion, and by the Direction of your Semi-Circles at each End, and the Lines upon the Curve Surface of your Cylinder. Then bore the Body of it from one End to the other, in ſuch Proportion that the Diameter of the Boring may be $\frac{1}{4}$ or $\frac{1}{5}$ of the Breadth of one of the Hollows or Flutes wrought into your Cylinder.

Then prepare little *Mortars* after this manner. Get ſome Wooden Cylinders ſo as to fit each Channel or Flute; hollow them out, and add Chambers to them (as may be ſeen in B) which Chambers ſhall be $\frac{1}{3}$ or $\frac{1}{2}$ of your Flutes in Depth, and the Breadth of $\frac{1}{6}$ only. Theſe Chambers are deſigned to hold *Corn Powder*.

Reinforce theſe *Mortars* ſtrongly with Paper Caſes on the Outſide, and nail them faſt in the abovementioned hollow Channels; whoſe Concavity they are exactly to fit; but as to the Length of them it ſhall be double of their Breadth. Theſe little *Mortars* muſt each contain a *Recreative Globe* made of Paper, but with Wooden Bottoms prepared after the manner we formerly directed, and their Chambers muſt be charged with *Corn Powder*. Then having traced out a Spiral Line from one End to the other of your Caſe or Tube, fix theſe *Mortars* upon it, (that is) in a Spiral Direction with reſpect to each other, and ſecure them faſt in your Flutes, by little Iron Staples driven into the Bottoms of them, and into the Sides of the Liſts or Interſpaces, and bind the Middle of them with an Iron Plate faſtened at each End upon the Face of the Interſpaces: And if after having done all this, you apprehend they are not ſufficiently ſecured, you may fix beneath them a Wooden or Iron Bracket. But before you thus fix on your *Mortars*, you muſt neceſſarily pierce little Holes into the Body of your *Caſe*, which muſt be filled with *Meal Powder*, exactly upon which you muſt place the Touch-holes of your *Mortars*. Every thing relating to this may be eaſily gathered from the *Figure*; in which A and B point out the *Mortars*, and C diſtinguiſhes the *Recreative Globe*. But here I muſt farther acquaint you, that there muſt be but one *Mortar* in each Channel or Flute. I ſhall not here repeat how you are to fill the Boring in the Middle of it, having mentioned it ſo often already.

COROL-

COROLLARY I.

All these *Tubes* or *Cases* may be contrived so as to be portable after the manner of *Clubs*. And to that purpose you need only add an Handle or Gripe to them, that you may manage them without any danger to yourself, and at the same time destroy your Enemies: And upon this Account they may not only be ranked amongst *Recreative Fire-Works*; but may also be allowed a Place amongst the most Serious and Military, by filling them with something of a pernicious Nature and Effect, and arming them on the Outside with such Things as are proper to do Execution. This Hint I thought proper to make here; but I shall in the Sequel have a proper Opportunity of speaking more fully on this Subject.

COROLLARY II.

Though these 7 last great *Tubes* might very properly be filled with those *Compositions* we formerly gave for *Water-Globes* and *Fire-Balls*; I shall nevertheless subjoin the following *Compositions* for their Use, which will be particularly adapted to them.

I.

Take of *Powder* 12 ℔; of *Saltpeter* 8 ℔; of *Coal* 4 ℔, and of the *Filings* of *Iron* or *Hammer-slaw* 2 ℔.

II.

Take of *Powder* 24 ℔; of *Saltpeter* 10 ℔; of *Sulphur* 6 ℔; of *Coal* 4 ℔; of *Colophone* 2 ℔; and of the *Raspings* or *Saw-Dust* of *Wood* 8 ℔.

COROLLARY III.

In describing the above *Figures* we often made mention of an Helical or Spiral Line to be traced round the Body of a Cylinder; I therefore think it necessary to touch a little upon the manner of doing it; to the end that you may be enabled to succeed not only in the Construction of our Tubes and Cases; but also to perform several Things in Engineering, whether Mechanical or Hydraulical. Now having met with a Passage in *Vitruvius* which answers exactly to my purpose, whereby he instructs us how to make the Helical Screw, or Spiral Machine for raising Water, which is said to have been invented by *Archimedes* long enough before *Vitruvius* was born; I shall here insert it. Attend then to what he saith.

‡ *There is a kind of Screw which raises Water with great Power, but not to so great an Height as the Wheel. The Construction and Propor-*

‡ Vitruv. Lib. X. Cap. II.

tions

tions of it must be thus ordered. Take a piece of Timber, whose Thickness or Breadth must be brought to consist of as many Inches as its Length does of Feet, and let it be made round. Divide the Periphery *of it at each End into* 4 Quadrants, *or into* 8 Semi Quadrants, *by* Radii *or Lines branching out from the Centers, and terminating in the aforesaid Peripheries; and let these Lines so agree and correspond with each other that the Timber being fixed upright, the Lines of each Base or End may be exactly perpendicular over each other: From the exterior Extremities of these Lines (viz.) at each End, produce right Lines which may join them together, so that between these Lines thus produced there may be included ⅛ of the Curve Surface of the Timber or Cylinder from one End to the other. Thus these Eight Spaces will be equal both in Length and Rotundity (or Breadth.) Being thus adjusted mark out oblique Lines or Diagonals between them, with Points upon each Line, continually following each other in an uniform Direction. The whole being thus ordered, take a thin Switch or Ruler of Willow, and anointing it over with Tar, or daubing it with any thing of that Nature, fix it in the Points of the First Diagonal, and from thence apply it to the Obliquities and Circuits of the other subsequent Diagonals. And thus proceeding on in a natural uniform Succession uniting and connecting the Points of your Diagonals together you will have your Helical or Spiral Line formed. And here you must observe that the more oblique your Diagonals are, the less frequent, and farther off will your Spiral Revolutions be from one another. Your Line being thus formed by an uniform Progression of Diagonals intersecting the Lines or Divisions of the Curve Surface of your Cylinder obliquely; hollow out a Channel in that Direction just after the manner of a Screw.*

Thus far *Vitruvius* concerning *Archimedes's Hydraulic Screw*; but if it can be possible that the above Quotation is not plain enough to instruct you in the Operation, you may consult the *Commentaries* of *Philander* and *Daniel Barbarus* upon the same Subject, who have handled it with greater Prolixity.

Farthermore *Mar. Bettinus* in his † *Ærario Philosophiæ Mathematicæ*, or his Treasury of Mathematical Philosophy, has a particular Way of generating a Spiral Line, which is by some supposed to be invented by *Albert Durer*. The same *Bettinus* gives us another method of doing it, which he took from ‡ *Pappus*; where he explains the Meaning of *Vitruvius* in the Passage above-quoted: I have here then taken from that Author the most compendious Method I could possibly find to instruct you in the Subject in hand, after having retrenched some little Superfluities that could no ways answer our Purpose. Thus.

Let a Right Line be given equal to the Perimeter *of a Cylinder, and upon one of its Extremities let fall or raise a Perpendicular; (which must be shorter or longer just as you propose to have the Revolutions of*

† Mar. Bett. Tom. I. Pag. 48. and 49. ‡ Pap. Lib. XIII. Coll. Mat. Prop. 24.

your

Fig. N.° 179.

Fig. N.° 175.

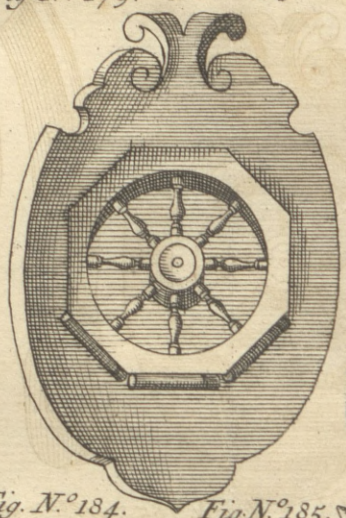


Fig. N.° 177.

Fig. N.° 180.

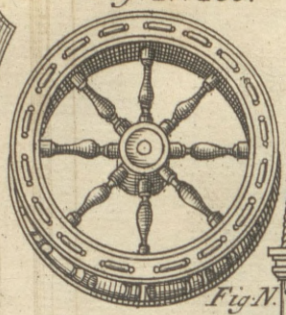


Fig. N.° 178.

Fig. N.° 181.

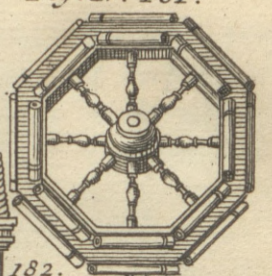
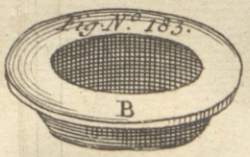


Fig. N.° 182.

Fig. N.° 183.



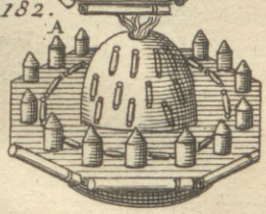


Fig. N.° 184.

Fig. N.° 185.

Fig. N.° 186.

Fig. N.° 187.

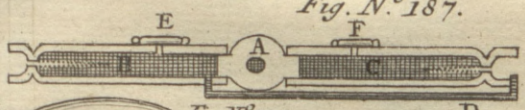
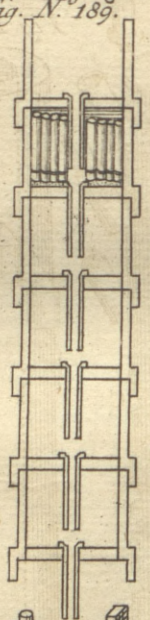


Fig. N.° 188.

Fig. N.° 194.

Fig. N.° 195.

Fig. N.° 189.



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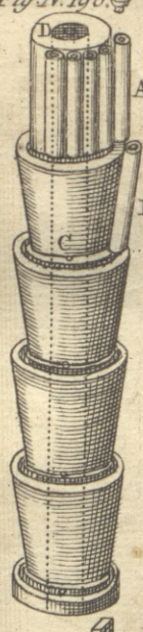

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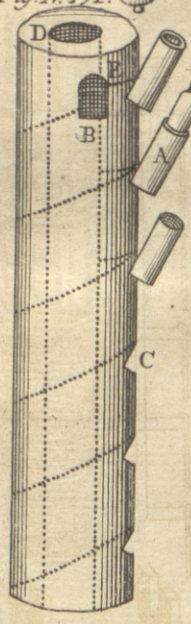

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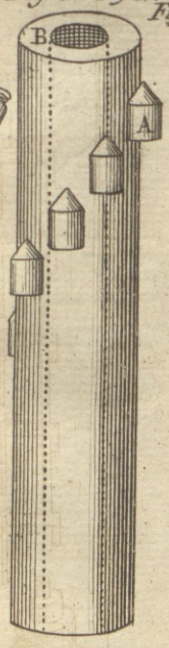

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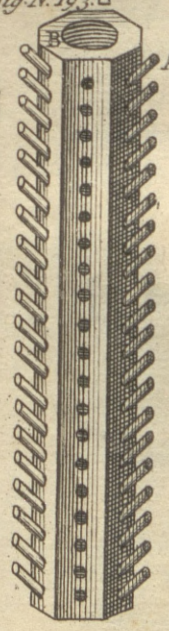

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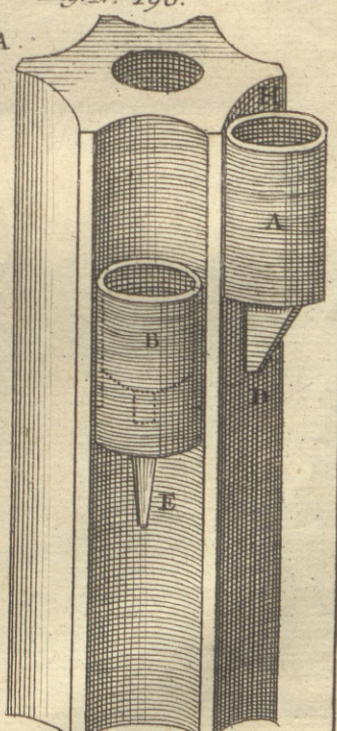

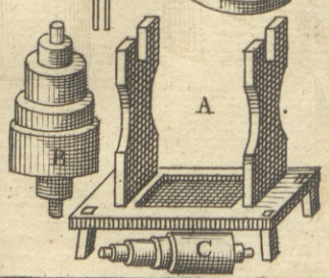

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P. F. Sculp.

your Spiral more or leſs frequent) then from the Upper Extremity or Ver-tex *of the ſaid Perpendicular, produce an Oblique Line or Hypothenuſe terminating in the other Extremity of the Baſe or given Right Line: This done, cut out this Triangle in Paper; and by circumvolving or wrapping the Baſe of it round the* Perimeter *of the Cylinder, the Hypothenuſe by its oblique Embrace will circumſcribe a certain Limit upon the Convexity of the Cylinder which will be your firſt Spiral; having then deſcribed it with a Pencil; apply your Triangle a ſecond time for a ſecond Spiral.*

The Right-angled Triangle by its Baſe ſhews the Circular Progreſſion of the lower Extremity of the Perpendicular: And the Perpendicular Side of it gives you by its Length the Progreſſion of the other Point of the Perpendicular upwards during the Time it was ſurrounding the Periphery or Perimeter.

I ſhall to this only add that we might by this laſt method very conveniently and readily deſcribe an Helical or Spiral Line, round the laſt great Fire Tube I gave you; (namely) by means of a Right-Angled Triangle whoſe Baſe is equal to the Perimeter of the Convexity of the Body, and its Perpendicular equal to the Height of it. Thus by applying ſuch a Triangle upon a Tube or Caſe of the aforementioned Sort, the Hypothenuſe will make a perfect Spiral upon the Convexity of it, upon which Spiral you muſt range your *Mortars* in the Flutes or Channels wrought into the Surface of your Tube, and then ſecure them as we before directed.

From the ſame Author you may alſo learn a Method of deſcribing a Spiral upon a Plane, which will be neceſſary for you to know, that you may be able to make the Serpentine Grooves in your *Artificial Shields* and *Eſcutcheons* as we ſaid above.

CHAP. XI.

Of ſeveral Recreative Pyrotechnical Machines *and* Engines, *compoſed of* Rockets, Crackers, Globes, Wheels, Bucklers, Clubs, Symetars, Swords, Poles, Staves, Tubes *or* Caſes, *and all ſuch like* Artificial Fires.

ALL that we have hitherto ſaid of *Artificial Recreative Fire-Works*, tends to this *Chapter* as to its Center: And all that we have hitherto taught in our Diſcourſes on the Method, Order and Faſhion of conſtructing all the foregoing *Fire-Machines*, has been no other than the Rudiments or *Apparatus*, to qualify or enable you to carry on and compleat the noble *Machines* exhibited on Popular Occaſions; in ſhort,

I have hitherto been only insinuating into you a Knowledge of the several Essentials, and furnishing you proper Materials to build with. In this *Chapter* I shall teach you the Assemblage of them, which is defined to be, *an ordering and disposing of the several Parts so that they may not hinder and embarrass one another; and the giving a Thing that Form and elegant Appearance which strikes the Eye of the Spectator in a pleasing manner.* Now this general Definition may be divided into several particular Branches, of which I shall here make Choice of two without specifying the rest which the *Architect* ought to be perfect Master of, and which the *Pyroboliſt* ought not to be wholly ignorant in. The first then shall be the *Thematism* (from the *Greek* Word Θεματισμος.) which signifies the *Decorum* and Gracefulness of any Pile; and is defined to be *the making the whole Aspect of a Fabric so correct, that nothing shall appear but what is approved and warranted by some Authority.* Now this last Quality of any Thing, is the Result of the profound Meditation, and assiduous Study and Diligence of the *Engineer*, in collecting all such Inventions and Contrivances as may be sutable to the Time and Place, where and when he exhibits his Work to the Public; and in accommodating them to the Rank of the Person by whom he is employed; in strictly keeping up to all such Things as seem to be in the most general Esteem amongst Mankind; in closely observing the Nature of Things; and in never attempting any *Chimerical* Impossibility, or ought else that might in any Degree shock and discompose the Rules of our *Art*.

The Second is *Oeconomy*, (from the *Greek* Word οἰκονομία:) This consists in *actual Practice, and in a perfect and mutual Connexion of Members or Parts; requiring the Exercise of the Judgment, and a Knowledge of why, and how it comes to pass that any particular Thing ought to be placed here and not there; why This should be in one Position, and That in another. It likewise considers Times, Seasons and Expences. And above all Things requires us to provide as much as we can towards our Safety and the Preservation of Life; and that, not with regard to ourselves only, but also with respect to those who might incur great Dangers through our Misconduct and Imprudence.* These are the two *Pyrotechnical Topics* which I propose to enlarge upon, and entertain you with in the Sequel.

Of the Thematism, Decorum, *or Gracefulness which is to be observed in the Ordering of our* Recreative Pyrotechnical Machines.

Both *Ancients* and *Moderns* have allotted four general Times or Occasions for exhibiting of *Artificial Fire-Works*. The *First*: At the Consecrations, Inaugurations, or Coronations of Popes, Emperors, and Kings; at the Receptions of great Princes and Generals; and at the Elections of City Magistrates.

Secondly:

Secondly: Upon any Victory obtained by Land or by Sea; upon the Acquiſition of any Province or City by Conqueſt; upon the Raiſing of Sieges, and all the happy Events of *War*. Again, upon the Concluſion of a Peace between two mighty States, and upon the Triumphant Entries of Emperors, Kings, and great Captains.

To this Claſs may be added Feſtivals, Anniverſaries, and Canonizations of the Bleſſed; for I think it but reaſonable that we ſhould devote Days of Joy and Benediction, in Commemoration of thoſe who have got the Victory over the World, by their Piety, Sanctity, Continence, Chriſtian Magnanimity, and all thoſe Virtues which render the Soul beautiful in the Sight of God.

Thirdly, Fire-Works may be very properly exhibited at Entertainments and the Celebration of Marriages.

And *Fourthly*; upon the Merry-makings of Friends.

As to the *Firſt* of theſe: It will be proper to prepare *Fire-Crowns*; to repreſent the Armorial Enſigns of Princes, Provinces, Cities, and People; to erect ſome Majeſtic Statue or *Coloſſus*, with a Number of ſmaller Figures about it, to perſonate the Subjects of the Prince, all dreſſed after the Faſhion of their Country, and paying their Duty and Homage to their Sovereign by all the Poſtures of Submiſſion. At the Inaugurations or Elections of Popes you may have recourſe to the *Myſtical Dream* of *Joſeph*, (as we find it recorded in *Holy Writ*) wherein he ſaw Eleven Sheaves of Corn, which ſubmitted to a Twelfth greater than They, and placed in the midſt of them. For Emperors, you may repreſent the ancient Ceremony amongſt the *Romans*, when they created their Emperors; which *Nicephorus Gregoras* mentions to this Effect. † Theodorus *upon the Deceaſe of his Father was lifted up upon a Shield and acknowledged as Emperor*; *and* Michael Paleologus *was admitted to the Empire with the ſame Ceremony.* Julius Capitolinus ſaith: ‖ *During this,* Cæſar Gordanus *was lifted up by the Soldiers, and ſaluted as Emperor. Ammianus Marcellinus* alſo in mentioning the Emperor *Julian,* who was raiſed to the Sovereign Dignity by the *Gallic* Troops; ſaith: *That being ſet upon the* Shield *of a Foot Soldier, and lifted up, he was in the midſt of the ſilent Multitude proclaimed Emperor, and honoured with the Diadem.* We find alſo in *Ado* of *Vienna,* that this Cuſtom was likewiſe obſerved amongſt the *Gauls* at the Creation of their Kings; for he ſpeaks to this Effect: Sigisbert *was put upon a* Buckler *after the manner of the Country, and proclaimed King in Prejudice of his Brother* Chilperic. And we find in *Aurelius Caſſiodorus,* that this ſame Ceremony was in Vogue amongſt the *Goths*; for ſpeaking of it he ſaith: ‡ *That the ancient* Goths, *their Fathers, had created their Kings according to the Cuſtom of their Anceſtors, by lifting them up upon a* Shield *in the midſt of drawn* Swords.

† Nic. Greg. Hiſt. Rom. Lib. III. Page 25. and Lib. IV.
‖ Jul. Capit. in Max. & Balb. ‡ Aur. Caſſ. Lib. X. Var. Epiſt. XXXI.

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This Ceremony, I ſay, may be properly applied to the Coronations of Crowned Heads: Repreſenting the King or Emperor by a Statue made up of *Artificial Fires*, and elevated upon a *Shield*; which may ſerve as an *Hieroglyphic* to denote the Warlike Genius of the Sovereign, and his Invincible Proweſs which had raiſed him to that ſublime Pitch of Glory; or at leaſt it may ſerve to admoniſh and excite him to an Acquiſition of that Heroic Virtue which is ſo neceſſary for the Defence and Preſervation of his Dominions. Or inſtead of this, He may be ſupported by the Armorials of particular Provinces and Cities, which will be the painted Voice, or perfect Repreſentatives of the Will or Choice of the People; but in the ordering of this Article, our *Pyroboliſt* muſt exert his good Senſe and Judgment, by doing nothing that may ſhock or give Offence to the Conſtitution of the Kingdom. Or you might upon the ſame Occaſion erect a Column, ſurmounted by an Imperial Crown or Royal Diadem with this Inſcription *Currenti*, or *to the Foremoſt*. This Device alludes to an ancient Cuſtom eſtabliſhed amongſt the *Poles*, after the Death of *Premiſlaus* or *Leſcus* the Firſt of that Name; for great Feuds ariſing amongſt the Grandees of the Kingdom who contended for the Crown, and none being able to think of any Way of deciding their Pretenſions, each of them perſiſting obſtinately in his Claim; the whole Affair was thrown up to the Diſpoſal of Fortune; and to that Purpoſe it was ordered that they ſhould all appear mounted upon Horſes, and ride a Race for the Crown of *Poland*, which ſhould be conferred on him who firſt reached the Goal. Now to tell you by what Stratagem one of theſe Competitors, called *Leſcus*, won the Prize; or to give you a particular Relation how he got Iron Bars laid under the Sand, to throw down the Horſes of his Colleagues of the *Race*, reſerving only a clear Path for himſelf, which he knew very well; I ſay, to dwell particularly upon this, is none of my Buſineſs; and thoſe who would be farther informed upon this Head, may turn over *Martin Cromer*'s *Hiſtory* (*Lib.* II.) of the *Wars* of *Poland*. To this I ſhall only add, that ſuch an Emblem may be applied to ſignify the Good Fortune of the Perſon raiſed to the Scepter or Crown; or to any particular Power over the People; but more eſpecially if the King is proclaimed by the unanimous Conſent and general Voice of the Nation, and as it were Elected preferably to a Number of Competitors who ſtood Candidates for the Sovereign Sway. This the prudent *Pyroboliſt* will know how to accommodate or adapt to the State of Affairs.

Princes likewiſe may be very ſeaſonably reminded at ſuch Times of the Viciſſitude of all ſublunary Things, and the Incertitude of Proſperity, by a Sight of the *Wheel of Fortune*, which may be made after the manner of one of the *Wheels* we have given you above. This Emblem was exhibited lately at *Copenhagen*, at the Coronation of *Frederic* the preſent King of *Denmark*; and I think it very proper on ſuch Occaſions; for (as *Pythagoras* ſaid) *Life is no other than a Wheel or Circle of Good*

Good and Evil. The *Wheel* then is a proper Emblem of Fortune; by which is meant *Divine Providence*; as we are taught by *Æſop*, who being interrogated by a Perſon, who asked him what GOD did? He replied (very much to the Purpoſe) *He abaſes the Lofty, and raiſes up the Humble.* To which we may add the following Words of the Sacred Text: *He hath put down the Mighty from their Seat; and hath exalted the Humble and Meek.* Again; remember the celebrated Sentence, which ſays, *That Human Things are a Circle.* And that other: *The Mutability or Viciſſitude of Things is very pleaſant to Man.*

You have for the ſame Occaſions another Repreſentation of *Fortune*, ſtanding upon a Ball, and ſpreading out a Sail ſwelled by the Wind, and with her Hair flying about in *Fig.* 203. Thereby to ſignify to thoſe Perſons who are raiſed to the Honour of Governing, and bearing Rule over Nations; that their Happineſs and Grandeur depend abſolutely upon the *Divine Will*; and that they are changable and unſtable like the Wind, very doubtful and of ſhort Duration; and to warn great Men not to ſuffer themſelves to be miſ-led by the falſe Appearances of a flattering Fortune, but on the contrary, to preſerve an Equanimity throughout their whole Conduct.

The *Figure* which we have given you in the Frontiſpiece of our *Work*, is a juſt Emblem of the Vanity of all Worldly Honours and Pomp; for what is a Man with all his Majeſty, his Dignity and Power, but a Bubble formed and ſwelled out by the Breath of a Child, from a little Soap and Water? I ſay, he is even leſs to be conſidered than ſuch a Bubble. You may then apply this to the Purpoſes above mentioned; and I cannot help thinking, that this Emblem drew its Origin from the Dream of *Conſtantine* the Emperor, juſt before the Turn or Change of his Fortune; wherein he thought, he ſaw a little Child taking very ſmall Brittle Balls out of his Father's Breaſt; from whence he drew very melancholy Interpretations and Conjectures concerning the Misfortunes which ſoon after overwhelmed him.

When great Captains and Generals take the Field, with a newly-delegated Command over the Armies of the State, the ingenious *Pyrobolift* may apply to them the Ceremony of the *Roman* Chiefs of Old upon the like Occaſions; which, according to *Servius Grammaticus*, was thus: † As ſoon as the Commiſſion was delivered to them, they entered into the Temple of *Mars*, and firſt ſhaking the ‡ *Ancilia*, and then the *Lance of the Statue*, they cried out, *Mars vigilia*; *Mars, watch.*

As to the public *Entries* of Triumphant Emperors and Chiefs returned from War, you may repreſent a thouſand magnificent *Fire-Works* proper to ſuch Occaſions. But were I to expatiate upon the ſeveral Particulars, I ſhould ſpin this *Chapter* out to a very immoderate

† Ser. Gram. Lib. VIII. Æn.
‡ *Ancilia*, were a Sort of *Holy Shields* kept in the Temple of *Mars*.

Length: And therefore, though I have a very rich Field before me, I ſhall only gather ſome of the moſt remarkable and principal Flowers for you.

The *Pyroboliſt* may then, upon ſuch Occaſions, repreſent every thing neceſſary or requiſite in a Triumph: Such as Triumphal Arches, Pyramids, Obelisks, Trophies, Statues, Spoils of the Enemy, Colours and Standards of the Vanquiſhed, the Captive Chiefs, with their Hands chained behind their Backs; together with the Inferior Priſoners all Dirty, Dejected, Squallid, and as it were half ſtarved; and alſo the lively Repreſentations of the Towns which are taken.

Again; you may prepare all the ſeveral Sorts of Crowns, ſuch as (were formerly) the *Golden Triumphal Crown*, the *Civic Crown* of *Oak*, the *Mural Crown* Winged, the *Vallarine* and the *Obſidional*; and in ſhort, the *Naval* or *Roſtral Crowns* compoſed of the Beaks and Prows of Ships. But that our ingenious *Pyroboliſt* may not wholly be a Stranger to the Pomp and Magnificence of the ancient *Roman Triumphs*, and that he may have proper Hints and Directions to work by, when Occaſion offers, I have here tranſcribed what *Johannes Roſinus* and *Thomas Dempterus* have collected of this Matter from ſeveral Authors concerning the *Roman Antiquities*. Firſt then *Roſinus* ſaith: † *As to what immediately related to the Pomp of the Triumph it was much after this manner. The Emperor* (*according to* ‡ Zonaras) *being dreſſed in a Triumphal Habit, adorned with Bracelets, crowned with Laurel, and holding a Branch of the ſame in his Right Hand; he convened the People, and after having applauded his Army in general, and extolled private Merit in particular, he divided the Money and Spoils; to ſome he gave Bracelets, to others Spear-Staves, ſome were preſented with Golden Crowns, and others with Crowns of Silver, on all which were inſcribed the Names of the Perſons; and the ſeveral Preſents beſtowed on them bore an immediate Relation to the generous and brave Actions they had performed. For he that had firſt ſcaled a Wall, had a Mural Crown given to him; if he had ſtormed ſome Caſtle, his Crown was ſuted to the Deed; if he had got the better in a Sea-Fight, he had a Naval Crown; and if he had behaved bravely in an Engagement of Horſe, he was diſtinguiſhed accordingly. But he that had ſaved a Citizen in Fight or in a Siege, or reſcued him from any conſiderable Danger, was firſt extolled in the moſt grateful Manner, and was afterwards crowned with an Oaken Wreath or Garland, the Honour of which was reckoned vaſtly to exceed that of all Crowns whether of Gold or of Silver.*

Nor was Virtue rewarded in particular Perſons only, but whole Cohorts and Legions were honoured with Preſents and Marks of Diſtinction. Thus a great Part of the Spoils was divided amongſt the Soldiery: There have been thoſe who have made Preſents to the whole Body of the People, and entertained them with Games at their own Charge; and if they had any

† Roſ. Lib. X. Cap. XXIX. ‡ Zon. Lib. II.

thing

thing left afterwards, they laid it out in erecting of Porticoes, Temples and other Public Works. Having diſpatched this Buſineſs, and offered up a Sacrifice, the Triumpher aſcended his Car, having thus prayed:

O ye Gods, by whoſe Nod and Command the *Roman Empire* has its Being and Increaſe, continue your favourable Protection of it, and preſerve it.

Then he was drawn through the Triumphal Gate; *being preceded in the firſt Place by Trumpets blowing Martial Sounds: After them came the Oxen deſigned for the Sacrifices, crowned with Wreaths and Garlands, and ſometimes with gilded Horns: Then followed a magnificent Show of Spoils and Arms, which being piled with wonderful Art were partly drawn in Chariots, and partly carried by Youths richly dreſſed: Then ſucceeded the Titles of the Conquered Nations, and the Images of the Towns they had taken; and ſometimes the Spoils were interſperſed with ſtrange Animals and Plants brought from the Conquered Country, and which had never before been ſeen at* Rome: *After theſe followed the Priſoners taken in War, the Captains and Chiefs of them being bound in Chains: And after them, immediately preceding the Emperor's Chariot or Car, were carried the Crowns of Gold, with which he had been complimented by Embaſſies from the Cities and Provinces, as was the uſual Cuſtom. Then came the Emperor himſelf in a ſumptuous Car, magnificently habited, and ſhining in a Triumphal Robe, crowned with Lawrel, and holding forth a Branch of the ſame in his Hand. The Triumphal Robe was Purple wrought with Gold, of which* Pliny Lib. IX. Cap. XXXVI, *and* Lib. VIII. Cap. XLVIII. *It was unlawful for any one to wear ſuch a Robe as this any longer than the Ceremonies of the Triumph laſted, as we find by the Hiſtory of* Marius, *of whom we read thus in* Plutarch, (*viz.*) *The Triumph being over* Marius *conducted the Senate into the* Capitol, *and whether he did it inadvertently, or whether he was elated by his Succeſs and good Fortune, he had the Inſolence to appear in the midſt of them with his Triumphal Robe; but ſoon perceiving that the Senate took Offence at it, he roſe up and laid it aſide, without making the leaſt Diſpute about it.* Dionyſius Halicarn. *ſpeaking of the Embroidered Purple Robe uſually worn by Kings, tells us, that it was unlawful even for Conſuls to aſſume it any more than the Royal Diadem; for* (ſays he) *thoſe* Regalia *or Enſigns of Royalty, were diſallowed to the Conſuls; becauſe they were apt to raiſe Envy, and were ſeemingly inconſiſtent with Liberty: Indeed, upon Account of ſignal Services, ſuch as the obtaining a Victory, the Senate conſented that the General ſhould be adorned with Gold, and clad in Purple. As for the Crown of Laurel, you may conſult* Plin. Lib. XV. Cap. L. *The Triumphal Car was in Imitation of a round Tower, and drawn moſt commonly by Horſes, four in a Yoke or a Breaſt; but when* Camillus *in his Triumph aſſumed White Horſes, he gave great Offence to the People, becauſe they were particularly Sacred to the King and Father of the Gods. Some choſe to be drawn by Stags, and others by Lions. Underneath the Emperor they hung the Idol* Faſcinus; (of which

which Plin. Lib. XXVIII. Cap. IV. ſpeaks thus:) *The God* Faſcinus *was not only the Protector of* Infants *but of* Emperors *alſo; and by hanging under the Car defends it, and protects the Triumpher from Envy, and commands Reſpect to his Perſon; or it was applied to admoniſh him to look back upon himſelf, and conſider that he was but a Man, though exalted to that high Pitch of Honour.* Zonoras *alſo ſaith, that a public Officer was drawn with him, who ſtood behind him holding over him a Crown richly adorned with Gems and precious Stones, and continually reminding him to look back upon himſelf, and conſider what he was; and take Care of himſelf for the Remainder of his Life, and not be puffed up with Vain-Glory and Pride. To the Car they alſo hung a little Bell, and Rods or Scourges, by which was ſignified, that he might fall under the ſame Calamity, and might be torn with Rods, and condemned to Death. For he ſaith, that thoſe who were condemned to any Capital Puniſhment for a notorious Crime, uſed to ring a little Bell, leſt any one by touching them inadvertently ſhould defile himſelf, and become a Sharer in their Guilt.* Pliny farther ſaith Lib. XXXIII. Cap. VII. *That it was the Cuſtom for the Perſon who Triumphed, to paint his Face with Vermilion, as was done by* Camillus, *but this Cuſtom was afterwards laid aſide: And to have his little Sons in his Car, an Example of which he gives us in ſpeaking of the Triumph of* Æmilius. *He likewiſe admitted his Kinſmen, if he had any, and his young Daughters into his Chariot. And thoſe that were full grown, were ſet upon the Horſes. Or if there was a conſiderable Number of them, they were drawn after him by ſingle Horſes. Cloſe after the Emperor's Car followed the Army both Horſe and Foot according to their Rank; and as many of them as had received Preſents from him as the Reward of their Bravery and Courage, carried their Gifts in their Hands; the reſt of them were crowned with Laurel, ſhouting with Triumphal Clamour, or chaunting Poetry upon the Occaſion, or breaking Jeſts upon one another, or the Spectators. The numerous Croud of People which flocked from all Parts of the Town and Country to behold this mighty Proceſſion were all decently habited, and moſtly in White, joyfully congratulating each other, and applauding their Heroic Countrymen: And in Honour to the Gods, all the Temples were filled with Garlands and Crowns, and ſet open as the Pomp paſſed by. In this Order the Emperor being conducted in Sight of the* Capitol, *he at once guided his Car towards it, and at the ſame time ordered the Captives to be carried to Priſon: Being come into the* Capitol, *he prayed to this Effect:*

I return thee my moſt ſincere and hearty Thanks, O thou beſt and greateſt *Jupiter*, and to thee O *Juno* his Queen, and to the reſt of the Deities the Protectors and Inhabitants of this *Fane*, in that it has pleaſed you at this Day and Hour by my Hands and Actions to preſerve the *Roman State*; Perſevere in your Benevolence towards it as you

you have hitherto done, cheriſh and proſper it, I humbly beſeech you.

And then they offered up Sacrifices in the moſt ſolemn Manner; and conſecrated Golden Crowns and rich Pieces of Armour to Jupiter, *which they hung up in the* Capitol. *And in the ſame Place a Feaſt was given at the Public Expence, and Money diſtributed to the common People, Man by Man; and what was left, was laid up in the Public Treaſury.* And a little afterwards: *They alſo erected Triumphal Columns, Statues, Arches, and Trophies, and other Monuments, as may be learned from* Plin. Lib. XXXV. Cap. II. *Of Triumphal Columns and Statues the ſame Author will inform you* Lib. XXXIV. Cap. V. VI. and VII. *and* Valerius Maximus Lib. II. Cap. V. Georgius Fabricius *ſpeaks thus of the Triumphal Arches* (in Roma ſua Cap. XV.) *Arches were formerly erected in Honour of thoſe who had conquered Foreign Nations, or gained great Victories for their Country: At firſt, they were rude ſimple Piles, when the Rewards of Virtue did not ſtir up an unwarrantable Ambition. In ſubſequent and more imperious Ages they were embelliſhed with the Ornaments of Sculpture. They were either of Brick, like that of* Romulus; *or of rough Square Stone, like that of* Camillus; *or of Marble, like that of* Cæſar *in the* Forum; *of* Druſus *with Trophies in the* Appian Way; *of* Trajan, &c. *The Arch was firſt Semi-circular, and afterwards Square as it went downwards, ſo that there was a vaulted Paſſage through it, and on either Side were added leſſer Paſſages or Poſterns. To the Vault of the middle Arch they hung Victory winged. Above this Vault there were Compartments or Pannels richly carved in* Relief *with Triumphal Repreſentations. This Magnificence took Birth in the Reign of* Auguſtus, *or a little before.*

Trophies were Trunks of Bodies, adorned with Military Ornaments and Arms, and ſometimes with winged Victories, *and a young Captive lying or ſitting down before them with his Hands tied behind his Back.*

Sometimes the Triumphing Chief was drawn to the *Capitol* by four white Horſes, as was done in the Triumph of the Great *Scipio*; ſometimes by Lions, as *Marc Antony: Pompey* the Great and *Caius Cæſar* by Elephants; *Heliogabalus* by Tygers, in Alluſion to *Bacchus*; and by Lions, alluding to *Mars*; or by great Dogs by an unparalleled and not-to-be-imitated Example: Add to theſe the Triumph of *Aurelianus Auguſtus*, who to ſignify the Cowardlineſs of the Enemy was drawn by Stags; that of *Nero*, who was drawn by Hermophradite Steeds; and the Inſolent Triumph of *Suſacus* King of *Ægypt*, who was drawn by Captive Kings, as you may read in *Joſephus* Book VIII. of his *Jewiſh Antiquities* Chap. X. Here you have Matter enough to employ your *Genius* and Art; on one Side, you may imitate the Sacrifices, on the other Side, all the magnificent Apparel of a Triumph, (*viz.*) Triumphal Arches, Pyramids, portable Statues, Trophies, Spoils of the Enemy, &c. All which you may diſpoſe in graceful Order.

If these two Authors I have been now quoting have not said enough to satisfy your Curiosity; hear what *Appianus Alexandrinus* saith of the Triumph of the great *Scipio: Being all crowned with Garlands, and preceded by Trumpets, they conducted the Chariots or Waggons laden with Spoils; they likewise carried Wooden Towers, Images, and Writings or Inscriptions expressing their fair Actions; after which came the Gold and Silver partly in rude Lumps and Masses, and partly wrought or coined; these were succeeded by the Crowns which had been sent by way of Homage or Acknowledgment; then White Oxen and Elephants; and after them the* Numidian *and* Carthaginian *Chiefs that had been taken in the War, who were succeeded by the Emperor's* Lictors *or Heralds richly clad in fine Purple; and after them a Croud of Minstrels and Singers after the* Tuscan *Manner, all crowned with Gold, playing and singing in regular Order; in the midst of these was a Buffoon adorned with Bracelets, and dressed in a long Gown trimmed with Golden Fringe down to the Ankles, who by his Gestures, Grimaces, and Ribaldry insulted the Prisoners, and excited the Laughter of the Spectators. Then came the Emperor himself surrounded by a Cloud of Incense and Odoriferous Perfumes; and drawn by White Horses, having Crowns on their Heads richly set off with Gems and precious Stones, and with Harnesses plated and studded with Gold; the Emperor himself sat exalted in a Gilded Car, habited in a Purple Robe after the Fashion of the Country, finely embroidered over with Golden Stars, holding in one Hand an Ivory Scepter, and in the other a Branch of Laurel; and accompanied by his young Relations, who were partly drawn with him in the Chariot, or laid hold on the Reins of his Horses; the whole Procession was closed up by the Body of the Army crowned with Wreaths of Laurel, some of them bearing Marks of Distinction as the Reward of their Bravery, and others stigmatized by way of Punishment for their Unworthiness; for as they knew how to applaud and distinguish the Brave, they also knew how to brand the Timorous and Unmanly with Infamy:* In Allusion to which *Juvenal* has this Satirical Fling.

Illinc cornicines, hinc præcedentia longi
Agminis officia, & niveos ad fræna Quirites,
Defossa in loculis quos sportula fecit amicos.

In *English:*

Trumpets Before, and on the Left and Right
A Cavalcade of Nobles all in White:
In their own Natures, false and flatt'ring Tribes;
But made his Friends by Places and by Bribes.

The Triumphal Robe was either embroidered, or powdered over with Golden Stars, or else stained or wrought with Palm-leaves; from whence

whence it was called *Palmated*. *Lucan* ſpeaking of theſe in *Book* IX. *Verſ.* 177, ſings thus:

——— *Pictaſque togas velamina ſummo*
Ter conſpecta Jovi.

Martial alſo mentions it *Lib.* VIII. and *Epig.* I.

Beſides what we have here related, the Ancients uſed to carry the Names of Towns, Mountains, and Rivers in their Triumphs, together with ſolid Figures of Caſtles, Cities, and Towers, which were commonly of Maſſy Gold or Silver, and ſometimes of Iron; but moſt commonly of Ivory, as we may learn from *Ovid* in *Lib. de Ponto Eleg.* IV.

Oppida turritis cinguntur eburnea muris.

In *Engliſh*:

The Ivory Towns begirt with Towered Walls.

And *Claudian Lib.* III. *de Laudibus Stilich.*

Oſtentarent ſuos priſco ſi more labores,
Et gentes cuperent vulgo monſtrare ſubactas,
Certarent utroque pares a cardine laurus,
Hæc alemannorum ſpoliis, auſtralibus illa
Ditior exuviis, illic flavente Sicambri
Cæſarie, nigris hinc Mauri crinibus irent:
Ipſe albis veheretur equis, currumque ſecutus
Laurigerum feſto fremuiſſet carmine miles:
Hi famuli traherent reges, hi facta metallo
Oppida, vel montes captivaque flumina ferent.
Hinc Libyci fractis lugerent cornibus amnes,
Inde catenato gemeret Germania Rheno.

In *Engliſh*:

If ſtill the Cuſtom was in Pomp to ſhow
The Victor's Glory, and the conquer'd Foe;
The North and South wou'd equally combine,
To make his Valour and his Conduct ſhine.
Here, ſhou'd the Warlike *German* Spoils be ſhown,
And there, the richer Trophies of a warmer Zone.
Here, the *Sicambri* with their Golden Hair,
There ſwarthy *Moors* with jetty Locks appear.
He by white Steeds be drawn in Godlike State,
Whilſt laurell'd Troops his Praiſes celebrate;

Here,

Here, vanquiſh'd Kings be led with doleful Pace,
There, Towns in Metal wrought, the Triumph grace;
The captive Rivers and each captive Hill,
In Model ſhewn, confeſs the Artiſt's Skill:
Here, *Libyan* Streams ſhou'd grieve with broken Urn,
There *Germany* in her chain'd *Rhine* ſhou'd mourn.

By this you may perceive that they uſed to carry the Images or Repreſentations of Rivers laden with Chains, to ſignify their Servitude. *Ovid* ſpeaks of this in *Lib.* IV. *de Ponto.*

Squallidus imittat fracta ſub arundine Crines, &c.

The ingenious *Pyroboliſt* may repreſent Rivers and Mountains alſo under Human Shapes in the moſt ſuppliant Poſtures ſaluting the Conqueror, and proſtrating themſelves at his Feet: The Rivers may be exhibited as preſenting him with ſeveral Sorts of Fiſh by way of Homage; and the Mountains may offer him their ſeveral Sorts of Ores in little Cars; but I need not ſuggeſt any thing farther to a fertile Invention; for ſuch will need my Aſſiſtance no farther than barely giving a few Hints of this Nature.

The Captives who were led in Triumph were chain'd by the Neck, the Arms, the Wriſts, and Legs: That it was the Cuſtom to chain them by the Neck, may be learnt from *Ovid*'s *Art of Love,* Book I.

Ibunt ante duces onerati colla catenis.

In *Engliſh:*

The Chiefs ſhall march before, their Necks oppreſs'd with Chains.

As for the Handcuffs with which they uſed to ſecure their Priſoners; we are informed, that they uſed to faſten the Left Hand of a Soldier to the Right Hand of a Priſoner; that if the former made any Attempt to eſcape, the latter might have his Right Hand at Liberty to draw and uſe his Sword in caſe of need. *Statius Lib.* XII. *Theb.* ver. 470, ſpeaks thus:

Me Pietas me duxit amor depoſcere ſæva
Supplicia, & dextras juvat inſertare catenas.

In *Engliſh:*

Thro' Love and Piety I met my Pain,
And gladly gave my Right Hand to the Chain.

Tertul-

Tertullian mentions the Fetters for the Priſoners Legs, in *Lib. ad Mart.* where he ſays, That *the Leg feels no Pain when the Soul is in Heaven.*

And *Sid. Apoll. Carm.* 2. *verſ.* 179.

Deſpiciens vaſtas tenuato in crure Catenas.

In *Engliſh:*

Deſpiſing pond'rous Chains which gall'd his meager Leg.

But what appears to me to be the moſt Shameful and Ungenerous of all, was their ſhaving the Captive Chiefs, as a Mark or Token of their Captivity; as *Propertius* obſerves in *Lib.* IV. *Eleg.* 12.

Teſtor majorum cineres tibi Roma colendos,
Sub quorum titulis Africa tonſa jacet.

In *Engliſh:*

Witneſs our Fathers Duſt which we revere,
T' whom *Afric* yielded up her captive Hair.

Ovid alſo ſays ſomething of it in *Lib.* I. *Amor. Eleg.* 14.

Nunc tibi captivos mittet Germania crines,
Culta triumphatæ munere gentis eris.

In *Engliſh:*

Now with new Arts, thou ſhalt thy Pride amuſe,
And *Curls*, of *German* Captives borrow'd, uſe.

They likewiſe frequently drew their Warlike Machines in their Triumphal Proceſſions; Witneſs *Tit. Liv. Lib.* IX. *Decad.* III. ſpeaking of the Triumph of *Metellus*; and in *Lib.* VI. *Decad.* IV. deſcribing that of *Fulvius.*

The ranſomed Citizens, Neighbours, Relations, and Kindred, *&c.* followed promiſcuouſly after the Triumphal Car with the Townſmen. *Valerius* ſays ſomething to this Purpoſe, *Lib.* V. *Cap.* II. (*viz.*) *That* 2000 *Captives which had been ſold by* Hannibal, *followed* Titus Flaminius, *&c.* Theſe, according to the Teſtimony of *Tit. Liv.* (*Lib.* IV. *Decad.* IV.) were all ſhaved.

This is what I have thought proper to collect concerning the ancient *Roman* Triumphs, for the Uſe of our *Pyrotechnician.* I ſhall now touch upon *Mars*, *Bellona*, *Victory*, *Nemeſis* and *Pallas*; all which may be

very properly introduced upon Popular Rejoicings on the Score of Warlike Atchievments, by adding to, curtailing from, or altering the several Circumſtances belonging to them, according as Time, Place, Opportunity and Expence will allow.

The Ancients repreſented the God *Mars* as all Fire and Flame; ſometimes drawn in a Triumphal Car, and at other Times advantageouſly mounted upon a Warlike Steed; here he bore a Lance in his Hand, and there, a Scourge. He was commonly attended by a Cock; thereby to ſignify, that Captains and Warriors ought to be perpetually upon their Guard, Vigilant in their Conduct, and Diligent in their Enterprizes. His Favorites and thoſe who ſhared the moſt in his Eſteem, were *Terror, Fear, Diſcord, &c.* as we find in *Homer, Iliad.* XIV. and *Virgil's Æneid.* VIII.

——— *Triſteſque ex Æthere diræ*
Et ſciſſa gaudens vadit diſcordia palla,
Quam cum ſanguineo ſequitur Bellona flagello.

In *Engliſh* thus:

The *Diræ* ſowſe from Heav'n with quick Deſcent,
And *Diſcord* dy'd in Blood with Garments rent,
Divides the Preſs: Her Steps *Bellona* treads,
And ſhakes her Iron Rods above their Heads. *Dryden.*

And *Æneid.* XII.

——— *Circumque atræ Formidinis ora,*
Iræque Inſidiæque, Dei comitatus aguntur.

In *Engliſh* thus:

Wrath, Terror, Treaſon, Tumult, and Deſpair,
Dire Faces, and deform'd, ſurround the Car,
Friends of the God; and Followers of the War. *Dryden.*

Statius enlarges his Train in *Book* III. of his *Theb.* ver. 425.

—— *comunt Furor, Iraque criſtas,*
Fræna miniſtrat equis Pavor aliger, ac vigil omni
Fama ſono, varios rerum ſuccincta tumultus,
Ante volat currum.

In *Engliſh* thus:

——— *Fury* and *Wrath* his Creſt adjuſt.
And nimble *Fear* directs the fiery Steeds;
Whilſt *Fame* flies on before to ſpread abroad his Deeds.

Some

Some have feigned that *Fear* drove the Chariot of this Warrior God. *Claudian* in *Book* I. in *Ruffin.*

Fer galeam Bellona mihi, nexuſque rotarum,
Tende Pavor, frænet celeres Formido jugales.

In *Engliſh* thus:

My Helmet let *Bellona* bring; *Terror* my Traces fit,
And pannic *Fear*, do thou, the rapid Driver ſit.

The ſame Author *de Laudibus Stiliconis.*

—— currum patris Bellona cruentum,
Ditibus exuviis tendentem ad ſidera quercum
Præcedit, lictorque Metus, cum fratre Pavore;
Barbara ferratis, innectunt colla catenis
Formido ingentem vibrat ſuccincta ſecurim.

In *Engliſh* thus:

Laden with Spoils, the Plunder of the War,
Bellona ſwift precedes the cruel Car;
Lifting on high an Oak conſpicuous from afar.
His *Lictors* Fear and Dread with trembling Pace
Surprize and chain the rude *Barbarian* Race.
With haggard Looks, and Robes ſuccinct *Affright*,
Wields an huge Pole-ax formidably bright.

Some Writers tell us that *Bellona* was the Siſter of *Mars*, and others, that ſhe was his Wife; and a third Claſs of them, aſſure us, that ſhe was both his Siſter and Wife. She was repreſented with her Hair diſheveled, and ſpred over her Shoulders, with a Torch in her Hand, as appears by *Silius Italicus*, *Book* V. *Pun.*

Ipſa facem quatiens, ac flavem ſanguine multo
Sparſa comam, medias acies Bellona pererrat.

In *Engliſh* thus:

Her Torch *Bellona* waving through the Air,
Sprinkles with clotted Gore her flaming Hair;
And through both Armies up and down does fly.

Some repreſented her with a Scythe in one Hand, and a Shield in the other.

Victory

Victory was pictured under the Form of a winged Virgin, in act of ſpringing up into the Air; bearing in one of her Hands a Branch of Palm, and on her Head a Crown. By the Wings of this charming Goddeſs, the Ancients gave us to underſtand, that the Events of War are doubtful and ambiguous; or that the Purſuit of the *Ambitious*, who are for puſhing their Fortune to the utmoſt Pitch, is not ſo properly a Race, as a real and reſtleſs Flight: Or elſe they gave her Wings, to ſignify with what a ſudden Swiftneſs ſhe roams from Place to Place, from one Country to another to win the Ears and Hearts of Men. In Temples her Statue was uſually ſupported by two others, who lifted and bore her up with their Hands.

Her Robe was either White, or dyed with Purple; for as this, is the Symbol of Majeſty; that, is the true Emblem of Peace, and Hieroglyphic of the Joy ſhe inſtils into the Hearts of thoſe whom ſhe pleaſes to favour.

Formerly likewiſe ſhe was repreſented without Wings, and ſitting upon a Ball. Some feign that by an extraordinary Prodigy the Wings of the Statue of *Victory* were burned by Lightning, which gave a Poet Occaſion to ſay:

Dic mihi Roma, alis cur ſtat Victoria lapſis
Urbem ne valet deſeruiſſe ſuam.

And indeed, I think *Rome* was in the right to deprive *Victory* of her Wings, ſince it was a Means to prevent her from going elſewhere.

You may then make a Statue ſtanding erect, and holding *Victory* in its Hands: By which upright Poſture, will be ſignified; That the Conqueror was not an heavy indolent Perſon, or one who would ſuffer any Opportunity to ſlip by him, when he had a View of Conqueſt, or of ſnatching Palms and Laurels from his Enemies.

Nemeſis was the Goddeſs of Vengeance, the Rewardreſs of Virtue, the Queen of Cauſes, the Soveraign Arbitreſs of Diſputes and Diſagreements; and was held by the ancient *Theologians* to be the Daughter of *Juſtice*. Her Statue alſo was winged, and trod upon a Wheel; becauſe of the wonderful Swiftneſs of her Action. Sometimes ſhe had a Bridle in one Hand, and the Meaſure of an Ell in the other. This may be very ſutably applied, when any Prince or great Captain has obtained a ſignal Victory over Rebellious Subjects, the Violators of Peace, and Diſturbers of the Public Tranquility; to the end that ſuch Evil-diſpoſed Perſons may learn by this Emblem, That God is the ſure and juſt Avenger of Crimes, and that he leaves no Perfidy unpuniſhed; and be warned another Time, how they attempt to exceed the Bounds preſcribed to them by Eternal Providence.

Minerva or *Pallas* is ſtiled by † *Cicero*, the Inventreſs of Wars.

† Cic. Lib. V. de Natur. Deor. Cap. XV.

She

She was pictured with a Pomegranate in her Right Hand, and an Helmet in her Left, according to the Teſtimony of *Celius:* For there are two Things which preſerve a Republic (namely) The *Union* of Hearts and Minds, which is figured by the Grains in a *Pomegranate:* And, Readineſs to defend it upon all Occaſions, which is expreſſed by the Helmet. An Helmet born in the Hand, and not upon the Head, ſignifies; That a brave and generous Prince covers his Country, and not his Head; that is, That he protects his Subjects, and maintains the Public Intereſt jointly with his own, at the Hazard of his Life: And therefore it is, that in Phyſic Gardens you ſee a *Scipio* with a World at his Feet, covered by his Head-piece.

As much may be ſaid of *Peace*; a Goddeſs to whom the Ancients conſecrated the Olive-Tree: It was from hence that *Ovid* framed a pleaſant Fiction in *Book* VI. of his *Metamorph. Fab.* I. Where he ſays, "That a Contention ariſing between *Minerva* and *Neptune*, about giv-"ing a Name to the City of *Athens*; which put the Aſſembly of the "Gods to a Stand, not knowing on which of the Two to confer the "diſputed Honor: *Neptune*, to win them over to his Intereſt, ſtruck "the Earth with his Trident, and cauſed a Horſe to riſe up from it: "*Minerva*, on the other hand, having the ſame View with *Neptune*, "cauſed an Olive-Tree to ſpring forth: Theſe ſupernatural Productions being the Emblems of Peace and War, the Synod of Deities gave "their Voices for *Minerva*, and ſo decided the Controverſy." By this Poetical Story we are given to underſtand, That Peace is infinitely more deſirable than War; and that the Laws of the former are more pleaſant and light, than the Yoke of the latter, which renders Life burthenſome and ſad. You may have Recourſe to this Emblematical Fiction, when any Prince has put an End to Wars, whether Foreign or Domeſtic, which had harraſſed his Country, and oppreſſed his Subjects.

The Dove with an Olive-Branch in her Bill is a true Symbol of Peace; and indeed it is what the Soveraign Head of the *Roman Church* (*Innocent* X.) has choſen for his Armorial Enſign; from whence ſome Men conjecture that God will be pleaſed to re-unite the Chriſtian Princes, under the Pontificate of this Spiritual Chief, and reſtore Peace to his People who have for ſo many Years paſt groaned beneath a Load of Miſery; and who wiſh for no Favour with ſo much Ardency, as the Bleſſings of an univerſal Pacification.

Now with regard to the Olive, the *Romans* were wont to repreſent *Peace* with a Branch of it in her Hand; or elſe with Ears of Corn; and crowned her with Laurel. Sometimes Painters and Statuaries placed a Roſe, and at other times a *Caduceus* or Wand in her Hand.

The greateſt Attendant, and moſt intimate Aſſociate of *Peace*, was *Felicity* or *Happineſs*; who was pictured as a Woman ſeated upon a Royal Throne, holding in her Right Hand a *Caduceus*, and in her Left

a Horn of Plenty †. For it is moſt certain, That the true Happineſs or Welfare of any State conſiſts in a perfect Union between the Prince and People, and in the Fertility of Soil, which can never be ſo well cultivated as in Times of Peace.

Theſe Statues may particularly ſerve by way of Decoration, to Triumphal Arches, and other Artificial Structures the Engineer may erect; Fig. 205. or they may be placed upon Pedeſtals, as you ſee in *Fig.* 205.

When any great Admiral ſhall have obtained a Signal Victory by Sea, you may repreſent a Triumphant *Neptune* upon the Water, drawn by Sea-Horſes; crowned with a Naval Diadem; darting a Trident with his Left Hand; and in his Right holding a Ship, with her Sails ſet to the Wind; upon whoſe Prow, *Honour* may appear, under the Form of a Youth; decently clad; crowned with a Wreath of Laurel; and bearing a Scepter in his Right-Hand, and a Pike in his Left: *Virtue* alſo may be ſeated at the Helm, under the modeſt Garb of a Matron; tho' ſhe was anciently repreſented by a young Man. *Neptune* may be on all Sides ſurrounded by a Number of Nymphs, Nereids, and Sea-Monſters, blowing in Conchs and other Sea-Shells, and in act of preſenting Crowns to the Brave who thirſt after Glory. In ſhort, our Engineer will have a fertile Field before him, when the Celebration of ſuch Occurrences requires him to bend his Invention this Way.

We are informed by Hiſtory, That *Duilius* was the Firſt of the *Romans* who triumphed for a Sea-Victory. *Valerius Maximus* tells us; " ‡ That whenever *Duilius* went to any Entertainment, he had a Torch, " or ſome other Light, carried before him; and that, Supper ended, he " returned Home with the ſame Equipage, and preceded by Trumpets " and Minſtrels; by which Nocturnal Ceremony he choſe to expreſs a " remarkable Succeſs in War."

Upon the whole, you muſt know that *Neptune* obtained the *Watry Empire*, for his having been the firſt Inventor of Navigation, for his having built the firſt Ships, and fitted out the firſt Fleet, of which (ſay they) he was appointed Commander in Chief by *Saturn*.

But before I cloſe up theſe Triumphant Repreſentations, I cannot forbear entertaining you with a Deſcription of that artificial and wonderful Piece of Machinery exhibited at *Paris*, upon the Victorious Return of His Moſt Chriſtian Majeſty *Louis* XIII. from the Siege of *Rochelle* in the Year 1628; and which was contrived by *Henry Clarmer* of *Norimberg*, one of the moſt celebrated *Fire-Engineers* of our Age, and whom we have taken an Opportunity of mentioning in the foregoing Part of this *Work*. *Paul Grodicki*, one of the beſt *Engineers* in *Poland*, ſpeaks of it to this Effect. " The *Artiſt* had raiſed an Artificial Rock in the " middle of the *Sein*; which appeared inacceſſible, for the Dangers " which ſeemed to ſurround it; and frightful, becauſe of its Precipices:

† Plin. Lib. XXXV. ‡ Val. Max. Lib. I. Cap. VI.

" To

" To this Rock he chained a Naked Virgin, about whom were ſeen " Nymphs running up and down in a confuſed Manner with lighted " Torches in their Hands, and bewailing the rigid Fate of the Captive " Maid. At length, there appeared a dreadful Sea-Monſter, of enor- " mous Gate, vomiting Fire and Flame in ſuch abundance, and in ſuch " various Redundancy, that he was equally the Dread and Admiration " of the Spectators: This prodigious Creature was carried by the " Stream towards the Rock, with ſeeming Intention to devour the Vi- " ctim deſigned for him; but at the Inſtant he had reached the Rock, " and was eagerly moving on towards his Prey, a young Heroe appeared " in the Air, advantageouſly mounted upon a winged Steed; who cow- " ring down with the Reins upon his Neck, and ſowſing directly " upon the Monſter, the Heroe ran him through and through with " his Spear; and from the Wound there ruſhed out a prodigious Quan- " tity of Artificial Fires. In ſhort, the Rock, the Monſter, the Heroe, " and the Maid, *&c.* were made up of *Artificial Fire-Works*, which " plaid inceſſantly for ſeveral Hours. Amongſt other Things, he re- " preſented the Arms and Name of the ſubjugated Town in Fiery Cha- " racters; together with the Royal Name of the King, and whole Sen- " tences of Triumph and Glorious Import; all which were ſeen ſcat- " tered up and down in the Airy Expanſe."

This fine Piece of Machinery was derived from the Story of *Andromeda*, the Daughter of *Cepheus* and *Caſſiope*, King and Queen of *Æthiopia*, who for her Mother's Pride and Vanity in boaſting that ſhe ſurpaſſed the *Nereids* in Beauty and Comlineſs, was by them taken, and bound to a Rock to be devoured by a Sea-Monſter; but *Perſeus* happily paſſing that Way in his Return to his own Country, delivered her, carried her away with him, and married her. *Propertius* mentions this in *Book* II.

Andromeda monſtris, fuerat dedicata marinis,
Hæc eadem Perſei nobilis uxor erit.

In *Engliſh* to this effect:

T' a direful Monſter of the Ocean Stream,
Andromeda expos'd; a helpleſs Prey!
Perſeus the deſtin'd Virgin did redeem;
And bore the ſuccour'd Maid his future Bride away.

It muſt be allowed, that the Thought of the Engineer, throughout this whole Piece, was extremely juſt and natural, and moſt pertinently adapted to his Subject; for the King was repreſented by *Perſeus*; the winged Steed, or *Pegaſus*, gave us to underſtand the martial and active *Genius* of that great Prince; *Andromeda* was the true Type of the *Ca-*

tholic

tholic Religion, at that Time oppreſſed by the *Proteſtants* of *Rochelle*; the Rock bore alluſion to the Town of *Rochelle* itſelf, and ſuted very well with the Etymology of it. In a word; the Monſter deſtroyed, and Maid delivered by *Perſeus*, figured to us, the *Reſtoration* of the *Catholic Church*, which had been doomed to Deſtruction by the *Proteſtants*, and the Suppreſſion of their Hereſy, and their Reduction to Servitude and Obedience.

This Fable may be very naturally applied, when any great Captain ſhall have compelled an Enemy to raiſe a Siege, and obliged them to quit any Place or Fortreſs, which they had obſtinately attacked; and reſtored Peace to thoſe who thought themſelves upon the Brink of Ruin.

The conquered Cities may be repreſented by young Damſels, or venerable Matrons (provided the Female Sex agrees with the Name of the Place;) who may be placed in ſome great Gate-way, as it were ſaluting ſome Hero drawing near, and ſhewing him, how all the Gates are opened to receive him; that the whole Town is devoted to his Intereſt, and that he has nothing to do but to take peaceable Poſſeſſion of it. This (as we are informed) was lately done at the Surrender of *Gravelinnes*, one of the prettieſt Maritime Towns in all *Flanders*, which was beſieged and taken by the Duke of *Orleans*.

But who is he that can give ſufficient Inſtructions in any *Art*, to ſatisfie the entire Bulk of his Readers? Do we not ſee every Day New Additions and Improvements tacked to old Inventions? And what was unknown to our Fore-fathers is now ſo common amongſt us, that one is almoſt aſhamed to dwell upon it. In our Days nothing is acceptable but what is New, diſregarding every Thing which has been formerly ſeen or performed. And therefore I ſhall have done with the Subject we have been here handling, and ſhall leave what elſe might be ſaid of it, and whatever can be drawn from what I have here inſerted, to the Fancy and Diſcretion of the Perſons who are led by their *Genius* or Profeſſion to cultivate our *Art*. Proceed we now to the *Vigils* or *Feſtivals*; and let us take in Hand the *Fire-works* which may be properly applied to the Celebration of thoſe Solemn Occaſions.

But I muſt here obſerve, that I believe our *Recreative Fire-works* and *Bonfires* derive their Origin from a certain Ceremony amongſt the *Ancient Romans*, upon thoſe Feſtivals which they held in Honour of their Falſe Gods. I ſhall therefore here produce the Teſtimony of ſeveral Authors, for your Information in theſe Ancient Rites, and to illuſtrate the Pomp of their *Artificial Fires*; but before I enter upon this, I muſt premiſe a few Words.

The moſt famous of all the Games in vogue amongſt the Ancients, were thoſe which they called *Secular*: If you would know the Origin of them, you may conſult *Valerius Maximus Lib.* II. *Cap.* 4. and other Authors. They were called *Secular* Games; becauſe they were celebrated

brated once every Hundred Years, which they commonly computed to be a *Seculum* or *Age*. *Valerius Publicola*, who was the first Consul after the Abolition of the Kingly Government, was also the first that instituted and celebrated them. But the last that held them was *Septimius Severus* with his four Sons, all of them exalted to the Consular Dignity; for *Zosimus* assures us, they were never revived afterwards; because the End of the succeeding Age was ruled by *Constantine Christianus* and *Licinius*. But *Orosius Lib.* VI. *Eutropius Lib.* IX. *Zonoras Lib.* II. and *Eusebius Lib.* VI. affirm that the two *Philips* (the Father and Son, who are thought to have been the two first Christian Emperors) held them at *Rome* with a great Concourse of *Jews* above a thousand Years after the Foundation of the City. Pope *Boniface* was the First who in Imitation of the old *Romans*, instituted the Christian Secular Year, (which we now call the *Great Jubilee:)* This he did in the Year 1300, under the Reign of the Emperor *Albert*. (See *John Vall. Lib.* VIII.) After him Pope *Clement* the VI, at the earnest Sollicitation of the *Romans*, ordered the Mysterious Ceremonies of the *Jubilee* to return every Fiftieth Year, and accordingly began with the Celebration of it at that Term in the Year 1350, under the Reign of the Emperor *Charles* the IV. In short, Pope *Xystus* the II instituted the Observance of it every 25 Years; which he confirmed by his own Example in the Year 1475, under the Reign of *Frederic* the III. To conclude, the *Roman Catholics* celebrate it this present present Year 1650 under the Pontificate of *Innocent* the X, at this Day the Head of the *Roman Church*, and under the Reign of the Emperor *Ferdinand* the III. Those who would know the Ceremonies usually practised in the Solemnization of this Mysterious Festival, may consult our famous Annalist *Paulus Piasecius* Bishop of *Premislaw*, who was at *Rome* in the Pontificate of *Urban* the VIII, where he carefully observed whatever he saw worthy of Notice; but if you would have the freshest Accounts relating to this Matter, you may be informed by those who return this Year from *Rome*; for the Ceremoninal varies considerably every Time. But let us now return to the *Secular Games* observed by the Ancient *Romans*; from whence to gather some Hints relating to the Decoration of our *Artificial Fire-works*. First then *Rosinus* speaks thus. † *The Time for celebrating the* Games *drawing near, Messengers were dispatched to all Parts of* Italy *to convene the People, and invite them to be present at those* Games, *which had never been seen before, and perhaps never would be seen again. Being then assembled, and the* Festival *near at Hand; fifteen grave Persons were presented to the* Public, *whose business it was to offer up Sacrifices in the* Capitol *and the* Palatine Temple; *and who being seated upon an Eminence, distributed the Offerings to the People; which were no other than* Torches *of* Pine-Tree, Sulphur, *and*

† Ros. Lib. V. Cap. xxi.

Bitumen; *but Servants and Slaves were excluded from these Presents, and it was unlawful for them to accept of any. Besides the Places already mentioned; the People assembled in the* Temple *of* Diana *upon the* Aventine Hill, *where it was the Custom to give them* Wheat, Beans, *and* Barley. *Then they began to watch as usual in the Sacrifices and Rites of* Ceres. *The Day being come, they repaired to the Banks of the* Tiber, *where they remained three Days, and three Nights, wholly intent upon the* Sacred Ceremonies. *After these Preparations they offered up Sacrifices to* Jupiter, Juno, Apollo, Latona, Diana, *the* Fates, Ceres, Pluto, *and* Proserpine &c. *To this purpose the* Prince *upon the Second Hour of the First Night caused three Altars to be erected, upon which he offered up as many Lambs, and with him the* Fifteen Venerable Men, *and having sprinkled the Altars with Blood, they burned the Victims together. This done; they raised a kind of Theatre, and lighted up a great Number of* Fires, Torches, *and* Lamps; *and sang Hymns adapted to the Solemnity, and began to celebrate their Spectacles in good Earnest; distributing* Wheat, Beans, *and* Barley, *to those who acted the Principal Parts; as had before been done to the whole Multitude in general. On the Morrow they repaired to the* Capitol, *there to perform the usual Sacrifices; and then assembled in the Theatre, to see the Games in Honour of* Apollo *and* Diana. *Upon the following Day the Noble Matrons went up to the* Capitol, *there (at the Hour appointed by the* Oracle) *to pray, to frequent the Banquets, and to sing Hymns according to Custom. In short; upon the Third Day they convened in the Temple of* Apollo, *on the* Palatine Hill, *where Twenty-seven Boys in ceremonial Habits, and as many young Girls having both Father and Mother living, declaimed in* Greek *and* Latin, *and sang* Pæans *to the Immortal Gods, recommending to them the Safeguard and Protection of their* Empire *and* People.

As for the *Decennia*, which were Games instituted by the Emperor *Gallienus* to be kept every Ten Years; *Trebellius Pallio* speaks of them to this Purpose. *After a pretty considerable Slaughter of Soldiers near* Byzantium; Gallienus, *as if he had done some mighty Feat, returned with the utmost Precipitation to* Rome, *and having convened the Senators he celebrated the* Decennia *with new Sorts of Games, with a new kind of Pomp, and with the most exquisite Voluptuousness. He first went to the* Capitol, *attended by all the* Senators, Knights, *and* Soldiery, *in white Habits; these were preceded by an innumerable Multitude of Men, Women, Servants, and Slaves, with* Wax Flambeaus, *and* lighted Lamps: *On each Hand were led in fine Order, an Hundred White Oxen with gilded Horns, and adorned with rich Silk Housings and Trappings of various Colours. On either Wing also* 200 *white Lambs and* 10 *Elephants (which were then in* Rome) *and* 1200 Gladiators *magnificently habited under the Disguise of Matrons, all shining with Gold, together with* 200 *Beasts of Prey of several Sorts, finely adorned; Waggons full of Mimics and all kinds of Actors; Boxers, fighting sham Battles; Fellows counterfeiting the* Cyclops:

clops: *In ſhort, it was wonderful to ſee them, and nothing was to be heard upon the Way but Shouts and Clamour. The* Emperor, *in the midſt of all this, appeared with the embroidered Robe, and palmated Tunic, attended (as we have ſaid) by the* Senators, Prieſts, Sacrificers, &c. *in their ceremonial Habits. With this Equipage he moved on towards the* Capitol, *having on each Hand* 500 *gilded Spears or Halberds for his Body Guard; together with* 100 *Enſigns, and the Banners, Gonfalons, and Streamers, of the Colleges, Halls, Temples, and thoſe of all the Legions. To theſe ſucceeded a vaſt Croud of People, diſguiſed like* Goths, Sarmatæ *and* Perſians, *who marched at leaſt* 200 *in a Troop.*

Theſe it muſt be owned were mighty fine Diverſions, and highly deſerving the Attention of ſuch great Men: But let them go on after their own Fancy without Contradiction; and let us leave it to the *Pyroboliſt*, to pick and chooſe what can anſwer to his purpoſe from theſe Whims; whilſt we take another Subject in Hand.

As for the Feaſts or Revels of *Bacchus*, which were commonly practiſed in the Night-time; we find great Variety of them amongſt Authors; but particularly in † St. *Auguſtin*, who tells us in his *City of God*, That not only the *Romans* (who held theſe mad Frolics in great Veneration) but that alſo the *Grecians* obſerved them with the moſt horrid Exceſſes and Inſolencies imaginable; running up and down the Streets and public Places of the City, like Madmen, bearing Torches and Pitchers of Wine which they drank of without Meaſure; but for the other infamous Cuſtoms committed at that Time, I will not fully my Page with any Rehearſal of them. However, in proceſs of Time the *Romans* grew weary of them, aboliſhed them, and baniſhed them from their Republic, and enacted ſevere Laws againſt them, and ordained heavy Puniſhments to be inflicted upon thoſe, who ſhould ever attempt to revive them in any Part of their Empire. *Alexander* of *Alexandria* tells us ſomething of the ſame Nature, with Relation to the Games called *Floralia*; or which were celebrated in Honour of *Flora*.

Diana had alſo her Feaſt-Days, which commonly fell out upon the Ides of *Auguſt*: The Days dedicated to her, were obſerved with Torches, Flambeaus and other Lights; as we find in *Propertius*, *Book* II. *Eleg.* 32.

—— ſed tibi me credere turba vetat,
Cum videt accenſis devotam currere tedis
In nemus, & Triviæ lumina ferre Deæ.

Ovid alſo *de Faſt.*

Sæpe potens voci frontem redimita coronis
Fœmina lucentes portat ab urbe faces.

† St. Auguſt. de Civit. Dei, Lib. X. Cap. XIII.

In

In *Engliſh* thus:

Oft-times with Temples crown'd, and clam'rous Cry,
The Woman bears the flaming Torch on High
From out the City Gates.

The Ancients alſo did ſet Days apart in Honour of *Ceres*, whoſe Feſtival was ſolemnized with burning Torches; becauſe ſhe firſt undertook the Search of her Daughter *Proſerpine*, who had been carried off by *Pluto* the King of Hell. *Lactan. Firm.* ſpeaks of it to this Effect: † *The Feaſt of* Ceres *was celebrated with burning* Torches; *becauſe ſhe is ſaid to have lighted* Torches *on the Top of* Mount Ætna, *when ſhe went in queſt of her Daughter, who had been raviſhed by the* gloomy God *of the Infernal Regions.* Thoſe who acted a Part in this Feſtival, ran about like mad People with Creſſet-Lights of Sulphur and Dirt, as may be gathered from *Juvenal Sat.* II. and Verſ. 91.

Talia, ſecreta coluerunt Orgia tæda
Cecropian ſoliti Baptæ laſſare Cotytto.

Lucius Ann. Senec. alſo:

Tibi votivam matres Grajæ
Lampada jactant.

In *Engliſh:*

To thee the *Grecian* Matrons throw the votive Lamp.

Thoſe who would be particularly informed upon this Subject, may conſult *Statius, Book* VII. of his *Theb.* Verſ. 412, and the ſame Author *Book* XII. Verſ. 132. *Claudian, Books* II. and III. *Mart. Book* II. *de Nupt.* *Ovid*'s *Epiſtle* II. from *Phillis* to *Demophoon*, &c.

To theſe three Feſtivals the *Athenians* added Lamps, which they vowed to *Panathenæa, Vulcan* and *Prometheus.* They held *Vulcan* to have been the firſt Inventor of *Fire*, and to have taught it the Firſt to Men, as we are told by *Iſter* in *Suidas* by the Word λαμπαδ@.

They not only uſed Torches and Flambeaus upon their Feſtivals; but alſo at the Initiations of all their Prieſts and Sacrificers; witneſs *Heſiod Lib.* IX. and *Juvenal Sat.* XV.

—— *quis enim bonus aut face dignus;*
Arcana qualem Cereris vult eſſe ſacerdos.

† Lact. Firm. Lib. I. Cap. XXI.

And

And *Statius Book* II. of his *Thebais*; towards the End of it.

Tuque Actæa Ceres curſu cui ſemper anhelo,
Votivam jaciti quaſſamus lampada myſtæ.

I will not here dwell upon the Feſtivals and Days dedicated to *Saturn*, which were alſo celebrated with Lights, as we are told by *Macrobius* †: But to all theſe we might add the Sacred Fires made of Straw, and lighted up by the *Savages* or *Barbarians*, over which they jumped three Times: *Ovid* ſings thus with regard to this Matter.

Tum licet appoſita veluti cratere camella,
Lac niveum potes purpureamque ſapam
Moxque per ardentes ſtipulæ crepitantis acervos
Trajicias celeri ſtrenua membra pede.

This Cuſtom has deſcended even down to our Days; for throughout all *Poland*, *Lithuania* and *Ruſſia*, and in all their circumadjacent Provinces, this Cuſtom is religiouſly obſerved; and even in *France*, the Populace both Men and Women, Young and Old, aſſemble together upon the Eve of the Nativity of St. *John* the Baptiſt, and after having lighted up Fires in all the Croſs-Roads, they dance about them, and jump over them in Token of Joy. ‡ The great *Olaus* aſſures us, that the ſame Cuſtom was obſerved in his Time in *Sweden*.

But we have ſaid enough of the Fires wherewith the Ancients uſed to celebrate their Vigils and Feſtivals. I might indeed enlarge conſiderably farther upon this Head, in Conſideration, that we infinitly ſurpaſs the Ancients, not only in Artificial Inventions, but alſo in Piety and Religion; however, leſt you ſhould think I rather deſign here to write a Book than a Chapter, I ſhall take the ſhorteſt Way of handling it, by ſaying nothing farther of it. Upon the whole, I deem it high time to touch upon the *Artificial Fire-Works* which are uſually practiſed at the Celebration of Nuptials, at Feaſts, and public Aſſemblies, and Merry-makings of Friends, which are in the greateſt Requeſt at preſent: For to ſay the real Truth of the Matter, the People of our Age are ſo Cloſe-hearted, and ſo Backward in paying the Veneration due to the great Author of all our Good, that we can hardly perſuade ourſelves to be at any Expence in the Celebration of Holydays and Seaſons ſet apart for his Worſhip, in the Commemoration of his Saints; (God forbid it ſhould ever be mixed with Superſtition, feigned Devotion, or Phariſaic Vanity;) but on the other hand, we are ſo liberal in our Feaſts, ſo profuſe in our Superfluities, and ſo prodigal in all our Debaucheries, that nothing is too Good, nothing too Dear, for us to be-

† Macr. Sat. Cap. VII.

‡ Ol. Lib. XV. Cap. IV. Hiſt. Gen. Sept.

ſtow

ſtow on the Gratification of our unruly Appetites. But if you are deſirous of being furniſhed with Hints towards the Preparation of *Fire-Works* for the Celebration of Sacred Seaſons and Occaſions, you may conſult the Holy Writers, in whom you will find an inexhauſtible Fund of Myſtical Treaſures: And therefore, if you ſhould ever have an Opportunity of exhibiting *Sacred Fire-Works*, you may have recourſe to the Inſpired Text, or conſult thoſe who alone have the Power of interpreting it, and of explaining the Myſterious Secrets, which the Divine Majeſty has been pleaſed to couch under it. For my part, I ſhall purſue my Intention of treating on Human Vanities, by inſtructing you in the Conſtruction of ſuch *Fire-Works*, as are uſually applied to Weddings, and the Carouſals of Friends, *&c.*

We have the Teſtimony of many conſiderable Authors to inform us, That it was cuſtomary with the *Greeks* and *Romans* to ſolemnize their Marriages, and public Entertainments with Fires. We find their Poetical Works almoſt every-where interſperſed with theſe Terms, *(viz.) Tædæ* or *Faces Jugales*, *Faces Legitimæ*, *Tædæ Geniales & Feſtæ*; that is, Nuptial Torches, Legitimate Torches, *&c.* *Claudian* ſings thus, *Book* II. in *Ruffin.*

—— dilecta hic pignora certè
Hic domus, hoc proprium tædis genialibus omen.

The ſame Author again,

Cum tibi prodiderit feſtas nox pronuba tædas.

And in an *Epithalamium* of *Honorius* and *Maria.*

Tu feſtas Hymeneæ faces ut Gratia flores
Elige.

Senæa the Tragicomœdian.

Et tu qui facibus legitimis ades
Noctem diſcutiens auſpice dextrâ,

Ovid alſo *Faſtor.* II. and elſewhere.

Conde tuas Hymenæe faces, & ab ignibus atris
Aufer, habent alias mœſta ſepulchra faces.

In *Engliſh:*

Go *Hymen*, ſtop the long-expecting Dames,
And hide thy Torches from the diſmal Flames.

Thy

Thy Preſence would be fatal while we mourn;
And at ſad Tombs muſt other Tapers burn.

Now in order to acquaint you, what the ancient Poets underſtood by theſe Fires and Torches; we will give you the Expoſition of † *Feſtus* concerning it, (*viz.*) Torches *were carried before the* Nuptial Pair *in Honour of* Ceres, *and the Bride was waſhed with* Water, *that ſhe might appear the more pure and chaſte to the Bridegroom; or they thereby ſignified, that ſhe was obliged to go through* Fire *and* Water (as we have it in *Engliſh*) *with her Husband.*

Lactantius Firm. gives us other Reaſons for it, (*viz.*) ‡ *Theſe two admirable Principles (meaning* Fire *and* Water) *have two Diametrically-different Properties and Effects,* (viz.) Heat *and* Moiſture, *by means of which* God *produces and ſupports all created* Beings. And a little lower: *One of theſe Elements is as it were the* Male, *and the other, the* Female; *the one is* Active, *and the other* Paſſive: *And therefore it was that the* Ancients *introduced the Uſe* (or *Sacraments* as the Original has it) *of* Fire *and* Water *to ratifie and confirm Marriages; and the rather, becauſe every Thing that has Life is compounded of* Heat *and* Moiſture; *and thus as every Animal is made up of a* Spirit *and a* Body, *the* Body *conſiſts in* Humidity, *and the* Spirit *or* Soul *in* Heat.

The Wood of the Pine was the moſt frequently uſed for theſe Torches, witneſs *Ovid Book* II. *Faſtor.*

Exoptat puros pinæa tæda Deos,

In *Engliſh* thus:

H' implores the Sacred Gods with Torches of the Pine.

Plutarch tells us they were ordinarily carried by five Youths amongſt the *Romans*; but with the *Greeks*, the Bride's Mother bore them herſelf, as we are told by *Dempſterus:* But I ſhall dwell no longer upon this, and ſhall haſten to the *Pyrotechnic Works*, which may be properly applied to the Solemnization of Nuptials.

I need not tell you that Marriages are Seaſons entirely devoted to Joy by the Friends of the contracted Parties, and celebrated by their Relations and Parents, *&c.* with certain mutual Liberties, and a thouſand innocent Paſtimes, Games, and Diverſions, which are ſo peculiarly adapted to ſuch Occaſions, that it would be highly improper to practiſe them at any other Time. And therefore ſince all decent Liberties are allowed in this Caſe, the *Pyroboliſt* will have a notable Foundation to build upon. But here, if he would follow the moſt general Rules that

† Feſt. Lib. VI. ‡ Lact. Firm. Lib. II. Cap. X.

have

have hitherto been laid down with regard to this Matter: He muſt give the firſt Place to Statues and Antics curiouſly wrought, with which he may adorn Fabrics, ſuch as imitative Palaces, Triumphal Arches, Caſtles and Fountains, *&c.* Amongſt other Decorations, he may repreſent a *Juno*, a *Venus*, a *Diana*, a *Cupid*, and all thoſe lovely Deities, as well Male as Female, whom the blind Heathens held to preſide over Marriages, *&c.* and whoſe Effigies you will find, or at leaſt Deſcriptions of them, in the poetical Works of both Ancients and Moderns. Now that I may lend a helping Hand to thoſe who have not the Convenience or Opportunity of reading ſuch Books (which are not always to be had eaſily) and that our *Pyrotechnical Novice* may not be at a Loſs, or be put to the trouble of unraveling the Intricacies of theſe poetical Fictions; I ſhall here undertake to lay before him whatever relates to this Matter in the cleareſt Light, and to illuſtrate it to him in the moſt lively and familiar Manner.

Juno, the Siſter and Wife of *Jove*, amongſt many other Appellations and Attributes beſtowed on her, by her Votaries was called *Lucina*; becauſe they imagined, ſhe opened the Eyes of Infants, and adminiſtred Light to them as ſoon as born; from whence alſo ſhe was called *Lucelia*. Or elſe ſhe was called *Juno Lucina*, *à Juvando & Luce*, (that is) from giving or helping to Light; wherefore it was, that Women called out upon her in the Pangs of their Labour. She was alſo ſtyled *Juno Jugalis*; either, becauſe the wedded Couple were under one and the ſame Yoke, from whence the *Latins* called the Husband and Wife *Conjuges* or Yoke-Fellows; or becauſe of the Yoke which was uſed at the Ceremony of their Nuptials.

Roſinus † deſcribes her Statue thus: *She was repreſented by a Woman ſeated upon a Throne; holding a Scepter in her Right-Hand, and having a Diadem upon her Head, which was veiled in the Clouds; ſhe was encompaſſed all round by* Iris *or the* Rainbow, *which was called* Juno's *Meſſenger; wherefore it was, that they figured the* Iris, *as a* Maid-ſervant, *ready to execute the Commands of her* Miſtreſs. *She had* Peacocks *at her Feet, on each Side of her, which were particularly called the Birds of* Juno.

Diana, the Siſter of *Apollo* and Daughter of *Jove*, was alſo called *Luna* and *Lucina* by the Ancients, who honoured her with many fine Attributes. They, amongſt other Things, held her to preſide over Births, and the Chaſe. The Women, as ſoon as delivered, ſacrificed to her, and made Veſtments for her. The Hunters celebrated her Feſtival in *Auguſt*, after a moſt pompous Manner with Flambeaus, and Torches, adorned with Ears of Corn, as we find in *Gratius*'s *Cynegetica*.

Spicataſque faces, ſacrum ad nemorale Dianæ
Siſtimus, & ſolito catuli velantur honore,

† Roſin. Lib. II. Cap. VI.

Ip-

Ipſaque per flores medio in diſcrimine lucis
Stravere armâ ſacris.

She was repreſented under the Form and Meen of a Woman, with her Hair looſe upon her Shoulders; armed with Bow and Arrow, and with her Forehead ſurmounted by a Creſcent. Sometimes ſhe was pictured in a Hunting Habit, in full Chaſe after a Stag.

Cleobulus tells us, That ſhe having one Day deſired her Mother to weave her a Gown; her Mother (knowing her natural Imperfections) replied; How is it poſſible for me to make a Garment to fit you, ſince your Form is ſo prodigiouſly given to Change? This may be very juſtly applyed to Whimſical and Capricious Men, who are as unſtable and various as the Moon; for in truth, they know neither Rule nor Meaſure.

Venus always ſhared greatly in the Veneration and Eſteem of the Ancients, as ſhe was the Goddeſs of Pleaſure, Delight, and Generation. The Poets would make us believe, ſhe was begot by a Spark or Seed of Fire which fell from Heaven into the Sea, and animated ſome of the Froth of that Liquid Expanſe; thereby figuring (as *Varro* tells us) the great Power of Fire and Water when duly tempered together and united.

She was ſometimes pictured as a young and tender Virgin, riſing out of the Sea upon a Scollop-ſhell. At other Times ſhe appeared as a perfect, mature Woman, holding a Conch-ſhell in her Hand, and having her Temples crowned with a Garland of Roſes and other Flowers. The *Graces* attended behind her, and *Cupid* and *Anteros* were on each ſide of her. Here you ſaw her exalted in a Triumphal Car, drawn by Doves, in alluſion to their Chaſtity; and there, by Swans to ſignifie that Love is contracted by Blandiſhment, Candor, and Sincerity; or that the Votaries of that Divinity are always outwardly Neat, Polite, and Genteel, but that they are like Swans, Black within; or elſe, That forgetting they muſt die they ſing like thoſe Birds when on the very brink of Eternity.

Again; ſhe was naked; to ſhew that an unbridled Voluptuouſneſs diveſts us of our beſt Dreſs, and ſends us away Empty-handed.

Phidias of *Elis*, that excellent Statuary, carved *Venus* with a Tortoiſe under her Feet (as we are told by *Plutarch in Præcept. Connub.)* to admoniſh Women by the Sloth of that Animal, to confine themſelves to their Houſes; and by the Silence of it, to learn Taciturnity.

The Lot which fell upon *Venus* at Play was formerly reckoned the moſt Lucky that could have happened (*viz.*) to have the Dies fall all upon one Side. This Statue then may be very proper in the public Congratulation of any Prince, who has enlarged his Dominions by a Happy Marriage, or by an Advantageous Alliance; not by the Aſſiſtance or Interpoſition of *Mars*, but of *Venus*.

Cupid was the God of Love, of Luxury, and all ſorts of Laſciviouſneſs. *Servius* deſcribes his Statue thus, according to *Roſinus*. " He " was repreſented as a Child; becauſe he is no other than an intempe- " rate Deſire of Things unclean and immodeſt; and, becauſe Lovers " do nothing but fool away their Time like Children.

They gave him Wings; becauſe there is nothing lighter than the Mind of a Lover, nothing more uncertain than his Vows; nor any thing more changeable than his Reſolutions. They gave him feathered Darts in his Hand, to ſignifie That the Sting of Repentance and Remorſe of Conſcience follow cloſe at the Heels of the Pleaſures of Love; Or elſe to ſhew the Doubtfulneſs of its Events, the Suddenneſs of its Courſe, and Shortneſs of its Duration. This obliged *Boëtius* to ſing thus, in his *Conſolation of Philoſophy*,

Omnis habet hæc Voluptas,
Stimulis agit fruentes,
Apiumque par volantum,
Ubi grata mella fudit,
Fugit & nimis tenaci
Figit icta corda morſu.

In *Engliſh* to this Effect.

Love, whoſe Empire knows no Bounds,
Pleaſes firſt, and then he wounds:
Like the Bee, this Infant-King,
Has both Honey and a Sting.

Philoſtratus has raviſhingly well expreſſed the Power of this amorous Paſſion. *Plutarch* calls him a *Dictator*, which was once the moſt Eminent Office in the *Roman* State; and others call him a *Soft Tyrant*.

He was formerly mounted upon a Lion, to ſignifie that he tamed all Things.

Philippus feigned, That he had torn the Thunderbolts out of the Hands of *Jupiter*, that he had ſtripped *Apollo*; taken *Mercury*'s Wings and *Caduceus* from him; diſarmed *Hercules* of his Club, *Mars* of his Sword, *Bacchus* of his *Thyrſus*, and *Neptune* of his Trident; meaning thereby, That none is able to withſtand the powerful Impreſſions of Love. In truth, all theſe beautiful Fictions may be very naturally and gracefully introduced, in your *Pyrobolic Edifices*, if you have Judgment ſufficient to guide you in the proper Application of them to Times, Places, and Perſons; but more particularly, upon the Marriage of ſome Brave and Generous Warrior, who till then thirſted after nothing but the Glorious Fruits of War; but is at length ſmitten

by

by ſome lovely Beauty, and diſarmed by the Hands of an agreeable Woman, who ſhall enſlave him under the Influence of Sacred and Legitimate Marriage. To theſe may be added the fabulous Story of *Hercules*, which tells us, he was ſo paſſionately fond of the charming Queen *Omphale*, that forgetting himſelf to be the mighty *Hercules*, he changed his Lion's Skin for the Effeminate Dreſs of a Woman; and employed himſelf in ſuch Works as can only become the Fair-Sex; ſuffered his Miſtreſs to put on his Martial Habit and Accoutrements; and what was farther extraordinary, was ſo complaiſant as to take Blows from her.

Love was alſo painted as a Child, Bareheaded, and clad in a green Mantle, upon the Hems of which were ſeen theſe Words, *Mors & Vita*, or Death and Life, which are the uſual Boundaries of this Paſſion, which for the generality runs into Extremes. Upon his Forehead he had this Device *Æſtas & Hyems*, or Summer and Winter, ſignifying that Friendſhip and Love ought to be always the ſame, and equal in Adverſity as well as in Proſperity. His Side was laid open over-againſt his Heart, where his Motto was expreſſed, *Longè & Propè*, or Far and Near; meaning thereby, that the Diſtance of Place from the Object beloved, is unable to diſunite the Hearts of true Lovers.

The *Graces*, which the *Greeks* called *Charites*, tho' they had no immediate Power at Weddings; yet as they were the conſtant Companions of the Goddeſs *Venus*, I ſhall ſay two or three Words concerning them. They were repreſented by three beautiful young Women, holding each other by the Hand in ſuch a Manner, that you ſaw only the back Part of the Firſt, a Profil of the Second, and the Third turned her full Face towards you. *Senecca* explains this various Poſition of the *Graces* after a very Rational Manner in his Book of *Benefits*. Why (ſays he) are the three Graces ſaid to be three Siſters, and why are they Hand in Hand? Some will have it, That the Firſt is ſhe who confers Benefits; the Second, ſhe who receives them; and the Third, ſhe who returns them; for it is certain that one good Action begets another; one Favour, draws Thanks after it, and a grateful Return of another Favour; and thus between Beneficence and Gratitude, you have a perpetual Circle of good Offices and Favours, reciprocally beſtowed and returned. They have always gay ſmiling Countenances, to teach us, That he who either gives or merits a Benefit, ought to be always in good Humour, and diſtinguiſhed by a ſerene Aſpect, and particularly the Perſon who receives the Favour; becauſe it is he alone that reaps the agreeable Fruit of Gratitude and Acknowledgment. They were young; becauſe the Remembrance of good Offices ought never to wax old, or decay; and becauſe they are always entire, diſintereſted, free from the ſordid Views of Gain, or Expectation of a Return. They were pictured naked, to ſhew their Liberality and Sincerity; and were ſometimes dreſſed in ſhining or tranſparent Robes, to remind us, That Favours and Benefits can never be concealed; but come to light ſooner or later, to the great Honour of the Benefactor.

Amongſt

Amongſt theſe Divinities you may likewiſe allow a Place to *Bacchus*, who alone of all the Gods was admitted into Feaſts and Weddings, where he moſt commonly preſided, as may be gathered from theſe Verſes in *Virgil Æn.* I. but we ſhall ſpeak more at large of him in his proper Rank.

Hunc lætum Tyriiſque diem Trojaque profectis
Eſſe velis, noſtroſque hujus meminiſſe minores.
Adſit lætitiæ Bacchus dator, & bona Juno.

In *Engliſh*:

So may the *Trojan* and the *Tyrian* Line,
In laſting Concord from this Day combine;
Thou, *Bacchus*, God of Joys and Friendly Cheer,
And gracious *Juno*, both be preſent here. *Dryden.*

Here I might introduce *Priapus* and *Flora* as Deities, which formerly aſſiſted at Nuptials amongſt the Ancients; did not common Decency reſtrain my Pen, and prevent me from putting my Reader to the Uneaſineſs of a Bluſh. And therefore, thoſe who would know any Thing particularly relating to them, may conſult others, who will inform them in what Poſture and Faſhion the Ancients repreſented them. However, that I may not conceal any thing from you, that Modeſty will ſuffer me to communicate: They pictured *Flora* as a Nymph crowned with Flowers, of a comely, genteel Meen, and of a pleaſant wanton Countenance. Thoſe who would know any farther, may have recourſe to *Pier. Valerianus* his *Hieroglyphics*; to *And. Alciat*'s *Emblems*, and to the *Genial Days* of *Alexander Alexandrinus*, where they may be furniſhed with a vaſt Number of fine Hints for all Sorts of *Fire-Works*. I think it is now Time for me, to touch upon *Fire-Fountains*, which may be exhibited upon all Occaſions, if the *Pyroboliſt* thinks fit.

Whatever *Engineers* repreſent in *Water-Works* by Jets, variouſly diſpoſed and contrived, may be exactly imitated in *Fire-Works*, as we ſhall hereafter evince. All thoſe *Artificial Fountains*, whoſe Name and Invention we borrow from the *Italians*, may be very eaſily contrived to hold a Quantity of *Artificial Fires*; which may be play'd off in ſuch Variety and Redundance, as to excite the Admiration of the Spectators. Theſe will be the more ſurprizing and pleaſing to the Eye, the more they are diſguiſed, and the nearer they approach to a Reſemblance of real Fountains for playing of Water; and by a little Induſtry and Art you may ſo order Matters, as to render it impoſſible for any one to gueſs by their outward Appearance, whether they be deſigned for Fire or Water: Therefore to carry on the Fraud the more ſpeciouſly, you may fill ſome of the Baſons of your Fountain or Fountains with freſh Water,

which

which may be thrown up by condenſed Air, if your Fountain be ſmall, or by a convenient neighbouring Fall of Water, if it be large; this may be done the more effectually to deceive the People, and to make them believe, that what they ſee is a real Fountain for Water.

Now in this Article, the *Pyroboliſt* will have an Opportunity of diſplaying his Judgment, by adapting his Statues and Figures to the Nature of theſe *Hydraulic Imitations*. As for Example, he may repreſent a *Neptune* drawn by Sea-Horſes; a naked *Arethuſa* recumbent; *Nymphs* and *Nereids* ſwimming and floating upon the Surface of the Water, and playing with Sea-Monſters. Amongſt other Things, *Helle* may appear upon a Ram, a *Siren* upon a Dolphin, and *Europa* upon a Bull; a naked *Naïad*, and the Story of *Actæon*, who ſurprized *Diana* and her Nymphs when they were bathing themſelves; or that of *Jonas*, who was thrown upon the Sea-ſhore by a Whale; and ſeveral other delightful Decorations which may be borrowed from ancient *Story*, whether Sacred or Prophane. I ſhall hereafter ſpecify in the moſt particular Manner, how all this is to be conſtructed. But tho' it might be neceſſary, that I ſhould here (at leaſt curſorily) touch upon the ſeveral Articles relating to *Nuptial* and *Genethlian Fires*, I ſhall deſiſt, as apprehending that thoſe, whoſe *Genius* is never ſo little Inventive, may form a thouſand fine Pieces from the Hints I have above-given, which may equally ſurprize the Ear, and aſtoniſh the Eye. Let us now conſider the fourth and laſt Sort of Occaſions, to which *Fire-Works* may be properly applied.

And this is, when Friends meet together to enjoy themſelves over their Cups, and in Scenes of Jollity and Mirth. I fancy, I need not inform you that *Bacchus* ordinarily preſides over all ſuch Occurrences, and that it is he, that bears the Bell away from all the other Divinities that might be introduced.

Therefore muſt we in ſuch Caſes erect Statues to this *Jovial God*, and all his revelling Train; whom we ſhall here delineate to you from the ſame Authorities we have all along reſorted to, for the Generation and Deſcription of the other Deities here mentioned. I ſhall begin with this toping God himſelf, and collect the beſt Account I can of him, for the Inſtruction of our *Pyroboliſt*.

Bacchus, according to the Teſtimony of *Diodorus* †, was the Son of *Jupiter* and *Semele*, and was bred up by Nymphs in the *Grotto* of *Nyſa*, between the *Nile* and *Phœnicia*, from whence he was ſtyled *Dionyſius*. He was called *Bacchus*, from a certain Crown or Garland which he wore on his Head, and which was compoſed of Berries; or elſe (perhaps) from the Word *Bacchari*, which ſignified the Shouts and Clamour made by thoſe who celebrated his Feaſts. He was ſometimes ſtyled the *Liber Pater*; becauſe he gives the free and unlimited Uſe of the Tongue; or becauſe he frees from Trouble, and blots out the Re-

† Diod. Lib. V. Antiq. Cap. V.

membrance of Misfortunes and Miseries in those who are his hearty Devotees. Hear *Ovid.*

Cura fugit, multo diluiturque mero,
Tunc veniunt risus, tunc pauper cornua sumit,
Tunc dolor & curæ rugaque frontis abit.

In *English:*

Full Bowls dispel all Care, and Joy afford;
Then enters Mirth; the Beggar grows a Lord;
Then far away are banish'd Griefs and Fears;
No thoughtful Wrinkle in the Face appears.

But *Ausonius* has in a more particular Manner traced up his Genealogy, his Appellations and Attributes, in *Epigr.* XXVI.

Ogygia me Bacchum *vocat.*
Osyrim *Ægyptus putat.*
Mystæ Phanacen *nominant.*
Dionyson *Indi existimant.*
Romana sacra Liberum.
Arabica gens Adoneum.
Lucaniacus, Pantheum.

In *English* to this Purpose:

B' Ogygia *Bacchus* I am deem'd.
By Ægypt *Osiris* esteem'd.
The Mystæ call me *Phanaces.*
The Indians say I'm *Dionys'.*
Th' *Adonis* of Arabia.
The *Panth'us* of Lucania.
Me Rome, her *Liber Pater* claims.
To each a God, tho' call'd by diff'rent Names.

Here is a fine parcel of Names of very different Signification; and you may make him appear under the several Characters above-expressed in your *Artificial Works.*

It is the universal Opinion, that he was the Inventor of Wine, and that he was the first who cultivated the Grape; whence *Tibullus* says, *Book* II. *Eleg.* III.

At tu Bacche tener jucundæ consitor uvæ.

In

In *Engliſh*:

But thou O gentle *Bacchus*, Planter of the Grape.

Macrobius deſcribes the Image of *Bacchus* to this Effect: † *The* Liber Pater *was repreſented as of an Age between Puerility and Virility; and ſometimes with a Beard as an old Man. On his Head he wore a Wreath or Garland of* Vine-Leaves, Fig-Leaves *or* Ivy: Vine-Leaves *and* Fig-Leaves *in Commemoration of the Nymphs* Staphila *and* Syca, *and* Ivy *in Remembrance of the Boy* Ciſſus, *who was turned into that Plant. He was ſometimes drawn in a Car full of Vine-Branches, by Panthers, Tygers, or Linces. On one Side of him, you ſaw the good old Man* Silenus *mounted upon an Aſs, attended by a great Number of* Satyrs *armed with* Thyrſi, *and the reſt of the* Bacchantes *proceeding in a diſorderly March before and behind him.*

He was ſometimes pictured with the Breaſts of a Woman, and with Horns and a Wreath of Vine upon his Head; mounted upon a Tyger; and bearing in his Right-hand a Bunch of Grapes, and in his Left, a great Pitcher to drink out of. Witneſs *Albric. de Imaginibus Deorum.*

He was Naked, to expreſs the Nature of Wine which can keep nothing a Secret.

And they mounted him upon a Tyger, to ſignify, That every Thing may be ſubdued by the Power of Wine.

Some ſay, he put *Lycurgus* to Death; meaning thereby, That Laws become ineffectual in ſuch Republics, as are immoderately addicted to drinking.

Dempſterus tells us, That *Bacchus* was alſo a Soldier, and that he made great Conqueſts in *India*. He writes thus: *The* Thyrſus *of* Bacchus *was a* Spear *twined round with Ivy, which his Army bore, when he led them to War againſt the unpoliſhed* Indians.

His Feaſts or Revels were always celebrated in the Night-Time with lighted Torches, as we have obſerved above.

The Companions of *Bacchus*, and thoſe who made up the greateſt part of his Train, were the *Sileni*, the *Satyrs*, the *Bacchæ*, the *Baſſarides*, the *Lenæ*, the *Thyades*, the *Mimallones*, the *Naiads*, the *Tityri*, the *Nymphs* and *Faunes*.

Silenus, the Foſter-Father of *Bacchus*, was pictured as an old Man with a bald Head, and mounted upon an Aſs: Giving us to underſtand by the doleful Equipage of this Man, That Drunkenneſs transforms the wiſeſt Perſon into a Brute, and renders the fineſt *Genius*, and moſt comprehenſive Wit, as ſtupid as the Beaſt on which he rode. Take the following Deſcription of him from *Virgil. Ecl.* VI.

† Macrob. Lib. I. Saturn.

—— *Chro-*

—— Chromis & Mnaſylus in antro,
Silenum pueri ſomno videre jacentem;
Inflatum heſterno venas, ut ſemper, Iaccho.
Serta procul tantum capiti delapſa jacebant:
Et gravis attrita pendebat Cantharus anſa.

In *Engliſh:*

Young *Chromis* and *Mnaſylus* chanc'd to ſtray,
Where (ſleeping in a Cave) *Silenus* lay,
Whoſe conſtant Cups fly fuming to his Brain,
And always boil in each extended Vein,
His truſty Flaggon full of potent Juice
Was hanging by, worn thin with Age and Uſe.
Dropp'd from his Head, a Wreath lay on the Ground. *Roſcom.*

It is of him that *Ovid* thus ſings, *Met. B.* IV.

Quique ſenex ferula titubantes ebrius artus
Suſtinet, & pando non fortiter hæret aſello.

In *Engliſh:*

His Staff, does hardly keep him on his Legs,
When mounted on his Aſs; ſee how he ſwags.

The ſame Author, *de Art. Am. Lib.* II.

Ebrius ecce ſenex, pando delapſus aſello
Clamarunt Satyri, ſurge, age, ſurge pater.

In *Engliſh:*

Th' old Soker's drunk, from's Aſs h'as got a Fall:
Rouſe Daddy, rouſe, again the Satyrs bawl.

In the *Roman* Games, the *Sileni* wore long Robes or Mantles wrought with ſeveral Sorts of Flowers.

The *Satyrs* were cloathed in Goat-Skins, and had hideous Masks on.

Faunus by the *Latins*, by the *Greeks*, *Pan*, was the God of Fields and Shepherds, and the Son of *Mercury*. He was pictured of a ruddy tanned Complexion; having Horns on his Forehead, and his Breaſt adorned with Rays. From the Navel downwards, he was all hairy and ſhaggy: He had Goat's Feet, and one of them was crooked. *Macrobius* mentions him *Lib.* I. *Saturn. Cap.* XXIII.

But

But to what Purpoſe ſhould I perplex myſelf any farther, with giving an Account of *Bacchus* and his mad Attendants? Is it not enough, that I have pointed out to you the Places where you may have your Curioſity upon this Head fully ſated? Let thoſe therefore, who have the Leiſure, turn over the Authors I have here quoted: As for me, I ſhall only give you ſome particular Inſtructions, concerning the *Decorum* and graceful Connection of our *Fire-Machines*; which done, I ſhall proceed to the *Oeconomy* and Diſtribution of them.

ADVERTISEMENT I.

It will be no ſmall Ornament to our *Pyrotechnical Machines*, if the *Engineer* has Art and Skill enough to introduce the Orders of *Architecture*; whether he would build a Palace, erect Triumphal Arches, Pyramids, Obelisks, Towers, Columns, *&c.* or only Parts of them: Or if he would prepare Fountains, or any other Pile, which muſt be regulated by the Rules of *Civil Architecture*. I am therefore of Opinion, that we ſhould raiſe theſe Ædifices after the *Ionic*, *Corinthian*, or *Compoſite Order*. It muſt indeed be allowed, that the *Doric Order* is the moſt Maſculine of all; and that it ſeems in itſelf to be the moſt proper for Triumphal Arches, Obelisks, Pyramids, and all ſuch Pieces as are erected in Honour of victorious Chiefs; but the public Tranſport and Joy being boundleſs upon ſuch Occaſions, it has for the moſt part been thought, that nothing can be too pompous for the happy Victor: Wherefore theſe Triumphal Works require to be very elaborate; to be decked with all the richeſt Ornaments of *Sculpture*; and to have their Aſpect perfectly magnificent. Things being thus, the *Compoſite Order* will anſwer your Purpoſe the beſt in all ſuch Caſes; for it carries with it a ſedate Gravity, and an Air of Royalty, together with an incomparable Gracefulneſs; from whence it was, that the *Romans* had ſo often Recourſe to it in Triumphal Ædifices; as may be collected from the Arches of *Conſtantine* and *L. Septimius Severus*, not to mention thoſe of *Trajan* and other *Roman* Emperors, which *Onup. Panvinius* has remarked, to the Number of Fourteen; and which are for the moſt part entire at *Rome* to this Day.

The *Corinthian* and *Ionic Orders* will ſerve extremely well for Weddings and Birthdays; for they are perfectly delicate, and (if I may uſe the Expreſſion) Effeminate; the Firſt of them being compared to a fine young Lady richly attired, and the Second to a ſober, reſerved Matron in a modeſt Garb. Theſe Orders alſo may ſerve for Holydays, and in the Celebration of Seaſons ſet apart for Devotion. But by the way, it will be proper that all theſe Works ſhould be expoſed to public View in the Day-time; for otherwiſe to what Purpoſe would it be, to beſtow ſo much Time, Labour and Coſt, upon a Thing which is not to burn above a few Minutes, and that at a good Diſtance from the Spectators, and amidſt the Darkneſs of Night?

Feaſts and Banquets alſo require the *Corinthian* Order; for upon ſuch Occaſions every one betrays his Luxury, Vanity and Prodigality, by all the Superfluities that can be deviſed.

The loweſt, and moſt ſimple Orders, will always be beſt for Fountains, *&c.* ſuch as the *Tuſcan* and *Doric* intermixed with the *Ruſtic*; for it is proper, that they ſhould have a rude and groſs Aſpect; but upon Occaſions which require ſomething more than Common, you may beſtow what Embelliſhments you pleaſe on them; always keeping a ſtrict Eye upon the Rules of *Architecture*. Or at leaſt (if they ſhould chance to be naked and plain) you may adorn them either with real or imitative *Rock-work*, according as either of them ſutes beſt with your Convenience.

ADVERTISEMENT II.

All your additional Ornaments muſt be judiciouſly choſen, whether they be in *Relief* or in *Painting*; ſo that there may be no Incongruity or Diſſonance ſubſiſting, between the Nature of the Thing celebrated, and the univerſal Conſtruction of your Machinery. Thus, upon the Inaugurations and Coronations of Kings, you may repreſent ſacred Emblems and Stories: For Triumphs, Things of Victorious Import: For Weddings and Birth-days, you may introduce Scenes of Mirth and Gayety, ſuch as Dances, *&c.* At Banquets and Carouſals, you may repreſent Fictions, expreſſing the mutual Joy and Careſſes between Friends. At Coronations, you may adorn your Work with Royal Crowns and Scepters: At the Conſecrations and Inſtallments of Biſhops, with Mitres according to their Rank; with the Armorials of particular Provinces and Cities; and with every Thing elſe, that bears Relation to the Quality of Perſons preferred to any eminent Station in the Church.

As to the Ornaments neceſſary for Triumphal Works, you may be ſufficiently inſtructed by *Trajan*'s Pillar; which the *Roman* Senate cauſed to be erected in token of their Acknowledgement, and lively Senſe of the great Merit and Virtue of that Emperor. *Geor. Fabricius* deſcribes it thus: † *The* Column *itſelf is cruſted over with* Parian Marble, *on which are expreſſed the great Actions of* Trajan, *and particularly the* Dacic War. *There you may ſee Repreſentations of Fortreſſes, Bulwarks, Bridges, and Ships; together with the Employments of the* Army; *ſome ſawing of Wood; ſome putting the Pieces of a Building together; ſome drawing out the Lines for fortifying the Camp; Pioneers at work upon the Trenches; ſome leading their Horſes to Water; others carrying Trophies, and marching as it were in Triumph; as alſo Corſlets, Helmets, Shields, and Bucklers, Belts, Clarions, Daggers, Javelins, Swords, Quivers of*

† Geo. Fab. Rom. Cap. vii.

Ar-

Arrows, &c. *On that Side, where the Inſcription is wrought, there are winged* Victories *accompanied by two Eagles.*

Prudentius ſpeaking of *Simmachus*, has very naturally deſcribed the Triumphal Arches, and the Ornaments with which they were enriched, in theſe Verſes.

Fruſtra igitur currus ſummo miramur in arcu
Quadrijuges, ſtanteſque Duces in curribus altis;
Fabricios, Curios, hinc Druſos inde Camillos, &c.

By which he gives us to underſtand, that the Triumphal Arches were adorned with pompous Cars; in which were beheld the Statues of mighty Chiefs, ſuch as the *Fabricii*, *Curii*, *Druſi* and *Camilli*; at whoſe Feet were Captives ſeen on bended Knees, and bound with rigid Chains.

To all this, we might add the ſeveral Sorts of *Military Garlands*, or the *Crowns* which we mentioned above; but the ſeveral Sorts of them muſt be moſt pertinently adapted to the Subjects celebrated; for Example; after a compleat Victory obtained in the open Field, you may uſe Crowns of Laurel; after the carrying of any Place by Storm, Mural Crowns winged: After a ſucceſsful Combat by Sea, Naval Crowns: Wreaths of Oak, for thoſe who have preſerved their Fellow-Citizens: For a Siege raiſed, Garlands or Crowns made of the Flowers of the Field; and of Olive, for thoſe who have reſtored Peace to their Country. To theſe may be added *Feſtoons* (ſo called from the *Latin* Word *Feſtivitas*, which ſignifies Mirth and Pleaſantneſs) in token of Joy. Now, *Feſtoons* are certain Ornaments compoſed of an agreeable Aſſemblage of Leaves, Flowers, Bloſſoms and Fruits. But you muſt take Notice, that in Triumphal Works the *Feſtoons* ſhould be adorned with very few Flowers or Bloſſoms; but muſt be enriched principally with Fruits, intermixed with Leaves and Branches of Laurel and Ivy: You may alſo amongſt your other Embelliſhments have ſingle Branches, and Foliages of Laurel and Ivy, Olive and Vine, as it were negligently diſpoſed of; but not at random, and in Places improper for them.

Upon Sacred Occaſions you may exhibit Cherubims, Palms, Pomegranates, Croſſes, Stars, and Divine Emblems, repreſenting Holy Myſteries; thereby to touch the Hearts of the Spectators, and beget in them Emotions of Piety.

The Ornaments and Embelliſhments proper for Machines erected for Weddings and Birth-days, *&c.* are Garlands of Roſes, Lillies, Violets, and other Flowers; together with ſeveral Sorts of Fruits, ſuch as Apples, Pears, Grapes of all Kinds, Plumbs, Olives, Medlars, Dates, Citrons, Lemons, Oranges, Pomegranates, Quinces, Melons, Cucumbers, and a thouſand other Fruits; all which may be bound together in *Feſtoons*, interſperſed with Leaves or Branches of Olive and Vine. Theſe will have a moſt beautiful Effect in your *Pyrotechnical Works.*

You

You may have alſo little Birds curiouſly wrought, and perching upon Branches of Palm, or Bunches of Grapes; together with Horns of Plenty, Ears of Corn, Sheaves of Wheat and Rye, *&c.* Again; at Feaſts and Carouſals, you may either paint or carve in *Relief*, Cups, Goblets, Flasks, Bottles, Flagons, Barrels, Tuns, Diſhes of Meat, Baſkets and Voiders full of Sweetmeats, Plates, Knives, and all the neceſſary Furniture of a Table; as alſo Muſical Inſtruments, *(viz.)* Citterns, Guittars, Violins, Baſs-Viols, Flutes, Cornets, Hautboies, *&c.* Upon the Celebration of Marriages, you may particularly introduce the Arms of the Bride and Bridegroom, which may be fixed upon the Frieze, (if your Piece be compoſed of Pillars) or upon the Shafts of the Pillars themſelves, ſet off all round with Flowers, Foliages and Ribbons. As for the Art of making the Names of the married Couple appear in Fiery Characters in the Air, you may turn back to what I ſaid in the *firſt Part* of *Book* IV. upon this Subject.

Your Fountains ſhall be adorned with all Sorts of Shells, and Stones of variety of Colours, little pieces of Rock-Work, glittering or tranſparent Stones and Pebbles, one and the other Coral, Splinters of Marble, and a thouſand Things of that Nature, whether Natural or Artificial. To theſe you may add Reptiles and Inſects of all Sorts, *(viz.)* Toads, Frogs, Serpents, Snakes, Lizards, Vipers, Graſs-hoppers, Beetles, Flies, Ants, Crickets, Bees, Spiders, Snails, Horſe-leeches, Cray-fiſh, and an infinite Number of other Creatures, which naturally haunt the Water, amongſt which may be interſperſed the ſeveral Sorts of Aquatic Herbs; together with the open Jaws of Lions and Bears. You may alſo repreſent ſeveral Animals, ſuch as Hedge-hogs, Weaſels, Rats, Rabbits, Hares, *&c.* together with Birds of amphibious Nature, ſuch as Geeſe, Ducks, Teal, Storks, Swans, Swallows, *&c.*

ADVERTISEMENT III.

The Garb or Dreſs of your Human Statues ſhall be choſen from the oldeſt Faſhions that can be taken from the Monuments of Antiquity; for it muſt be allowed, that nothing pleaſes the Eye more, than the ſeveral Habits which were the Mode amongſt the ancient *Romans*, &c. *(viz.)* the *Toga*, *Sagum*, *Prætexta*, *Trabea*, *Paludamentum*, &c. all which are ſtill viſible in what Reliques we have of the ancient Magnificence, whether Buildings or Medals. The particular Faſhion and Uſes of the abovementioned Habits may be found in *Nonius Marcellus*, *Juſtus Lipſius*, *Roſinus*, *Dempſterus*, and in others.

You may alſo cloath your Statues in the Skins of the Lion, Tyger, Leopard, Linx, Panther, Wolf, Bear, or ſuch like Beaſts of Prey; in Imitation of the Heroes of Antiquity, who clad themſelves in the Spoils of thoſe ravenous Creatures.

To all this, we might add the ſeveral Sorts of *Military Inſtruments*, which will be the more agreeable, the more they are conceived in the Guiſe, and bear the Appearance of rude Antiquity.

And therefore, I think it would be an ornamental Addition to our Works; if we painted or wrought in *Relief*, the *Fundæ* or Slings, the *Fuſtibuli*, Bows, Croſs-Bows, Javelins, Lances, Spears, Partuiſans, Pikes, Half-pikes, Axes, Pole-axes, Clubs, Swords; add to theſe, Shields, Bucklers, Targets, Corſlets, Breaſt-plates, Cuiraſſes, Creſts, Gantlets, Knee-pieces, and all the Pieces of Armour and Arms, which were in Uſe amongſt the ancient *Romans*: You may alſo introduce the old-faſhioned Fire-Locks, Bows, Arrows, and Quivers uſed by our Forefathers: All theſe will be very natural Embelliſhments, to Statues, Trophies, Triumphal Arches, *&c.* In ſum, to expreſs much in few Words; you muſt make it your utmoſt Endeavour to cultivate a Variety in all your grand Pieces, that you may never cloy your Spectators with an inſipid Repetition: But on the contrary, let your Invention be perpetually on the Wing, that you may always have it in your power, to ſurprize them with ſomething altogether new, perfectly natural, and judiciouſly underſtood: And thus by anticipating, or rather exceeding their Expectations, you may expect the public Applauſe in Reward for your Elegance and Induſtry; for tho' (as we are told by a conſiderable Author) *Things* done in the common Road may often adminiſter Pleaſure, they ſeldom or never excite the Admiration.

Of the Oeconomy, *or Diſtribution of* Artificial Works, *in* Recreative Pyrotechnical Machines; *and of ſeveral other Things relating to the ſame Subject.*

THE Explication of the *Thematiſm* or *Decorum*, neceſſary to be obſerved in our *Pyrotechnical Machinery*, has been conſiderably more prolix than I at firſt foreſaw: But I hope to handle the Subject now entered upon, after a more compendious Method; and that, by means of certain ſuccinct Rules, which I ſhall here lay down for your Inſtruction in the *Oeconomy* and Manual Practice of this Branch of our Art. They are thus:

I.

As ſoon as the *Engineer* has conceived a fine Thought for his *Pyrotechnic Works*, it will be abſolutely neceſſary that he be able to expreſs it in Drawing, the three Branches of which are *Ichnography*, *Orthography*, and *Scenography*. I ſay, it will be proper that he be a tolerable Maſter of *Deſign*; or at leaſt, that he be able to ſketch or *crayon* a little (as *Vitruvius* has it) that he may give the Perſon who employs him, a View of his intended Work upon Paper.

II.

It will not be enough, that he barely know how to sketch out his Deſign upon Paper; but it will be proper alſo that he be dextrous enough to make Prototypes and Models of it in Wood, Wax, Plaſter, Paper, or Paſteboard, *&c.* ſo that by this means any Deformities or Irregularities may appear obvious, and undergo a ſutable Correction, before he begins the Piece itſelf.

III.

As ſoon as your Deſign is brought to ſuch a Point as to meet with Approbation; you are in the firſt Place to conſider the Charge and Expence allowed for compleating it; that you may be able to ſquare your Work to your Purſe. You are then to treat with Workmen, whoſe Aſſiſtance you may ſtand in need of, and contract with them for their Labour, and the Materials they are to furniſh you with. It is here that our *Engineer* will have an Opportunity of diſplaying his Honeſty, by ſhewing how faithful and juſt a Manager he can be of the Wealth of others: And it will be no difficulty for him to acquit himſelf with Honour in this Caſe, if he does not inſiſt upon ſuch Things as are hard to be procured, and conſequently very chargeable; or if he has not his own Intereſt, and ſordid Lucre at Heart; or if with a View of future Preſents from the Workmen, he does not ſquander away what he is entruſted with, and what he will be obliged to render a ſtrict Account of, if not in this Life, in the next.

IV.

Being entered in good earneſt upon the Work, the *Engineer* is to take particular Care that the Workmen do their Duty to a tittle, and that they punctually obſerve all the Rules of our *Art*, in the Conſtruction of *Rockets*, *Crackers*, &c. to the end that the Whole may redound to his Credit, and have an Effect worthy of the Expence.

V.

The Carpenters ſhall firſt make the Carkaſs or Frame of the whole Machine, with Timbers, anſwering to the Proportions of the Model which ſhall be given to them: I here ſpeak of large Ædifices, ſuch as Palaces, Triumphal Arches, Towers and Caſtles, *&c.* for as to Columns, Pedeſtals, Fountains, Obelisks, Pyramids, Human Statues, and Figures of Beaſts; they all require to be conſtructed after a particular Manner. Tho' the Order we are here ſpeaking of, may be obſerved in the Conſtruction of ſome of theſe laſt, as may be remarked in the Re-
Fig. 197, and 198. preſentation of a Dragon in *Fig.* 197 and 198. In the firſt of which you have a Sight of the Bottom-Piece or Foundation of the whole Figure, and the other gives you the Form of it, and ſhews you the Order and Diſpoſition of all the *Pyrotechnical Works* withinſide. But as for grand and conſiderable Machines, you may perceive the *Orthography* and *Sce-*
Fig. 204. *nography* of them, in the Rampart of a Caſtle diſtinguiſhed by A, in *Fig.* 204. It will be very eaſy to erect Towers, whether round or many-

ſided,

ſided, Columns, and Obelisks (provided they are not very large) upon the Trunks or Stumps of Trees, or upon great round, or many-ſided Blocks of Timber: Theſe may be ordered much after the ſame manner with the Caſes or Tubes which we touched upon in the foregoing *Chapter:* (Conſider the *Figure* of the Tower Number 204; the Form of which does not vary much from the Caſe deſcribed and repreſented in *Fig.* 193.) Now the larger Sorts of theſe muſt be built with ſtrong Beams, Rafters, and Planking, which muſt contain within them a good quantity of Caſes of Compoſition, and other Artificial Works: Add to theſe the uſual Embelliſhments, (*viz.*) Pilaſters, *Paraſtatæ*, Architraves, Capitals, Pedeſtals, Columns and Pyramids, all which may be made of Boards, or at leaſt formed of four, or more Spars, perpendicularly erected upon the Angles of the Baſe, or terminating in a Point at Top; (which is natural to a Pyramid;) after this manner you may make the Frames and Carcaſſes of Parallelopipeds, Polyhedronic Priſms or Pyramids, and then cloath them with waxed or pitched Cloths, or coat them over with Paſteboard: Theſe may be filled with one or ſeveral Sorts of Caſes, Sky-Rockets ready ſticked, and neatly diſpoſed in the Interſtices between the Caſes, and againſt the Sides of the Pile or Machine itſelf. Fig. 193.

VI.

Human Statues, and Figures of Beaſts may be ordered two Ways.

Firſt, The Statuary or Carver muſt cut out the Bodies in Wood with all their Lineaments and Muſcles according to the Proportions given to him, and according as he is directed, he muſt make them either naked or cloathed. Then taking them and anointing them over with Soap or Wax, they muſt be coated over with Pulp or Paſte of Paper, kneaded or mixed up with Glue Water; which Coating ſhall be 2 or 3 Lines in Subſtance. It muſt then be dried by a gentle Fire, and as ſoon as the Skin or Coat is thoroughly dried, it ſhall be divided into two Parts, that is, it muſt be cut with a Knife cloſe home to the Wood, on each Side from the Crown of the Head to the Soal of the Foot; and thus taking off this Paſteboard Skin you will have the hollow Image of a Man or Beaſt. In the ſeveral Cavities of it, ſhall be fixed one or more Caſes of Compoſition, which muſt be previouſly ſhaped according to the Curvatures or Flexions of the Body, and well re-inforced or woulded to ſecure them from flying abroad, or ſplitting by the Violence of the Fire, before they have performed their due Effects; and it will be proper to fix them upon ſome firm Support, that they may be immoveable; which done, they muſt be hid in the before-ſpoken-of Paper Skin; taking Care to paſte the Joints and Creviſes very ſubſtantially together.

There are thoſe who only incloſe one Caſe within the Body or Skin, as may be obſerved in the Statue of *Fortune* in *Fig.* 202. But there are others, who dextrouſly fill the Arms, Legs, Thighs, Hands and Feet with *Running Rockets*, or *Crackers*, or Caſes of *Compoſition* curiouſly Fig. 202.

diſpoſed

diſpoſed of, and having Communication with each other by little Trains or Fuzes, ſo that they ſucceſſively conſume one after another. The Contrivance of this may be clearly obſerved in the Statue of *Bacchus* in Fig. 200. *Fig.* 200: But I muſt here remind you that the whole muſt be fixed upon a ſolid Foundation, ſo as to be immoveable, and not be in a tottering Situation: Wherefore it will be farther neceſſary, that the Neck, Arms, Reins, Thighs, and Legs ſhould be re-inforced with Iron Plates, or Rods, bent and turned, ſo as to humour and fit the ſeveral Angles and Flexions of the Body, according as the whole Frame of it leans more or leſs, and according as the Limbs are more or leſs contracted or ſtretched out. In ſhort, the whole Inſide of the Body muſt be ſtrengthned with Iron Plates or Rods, if it happens to lean either Forwards or Backwards, to the Right or the Left. Now as to the Method of finding the Openings of the ſeveral Angles formed by the various Flexions and Curvatures of the Body, you may eaſily have them by the Aſſiſtance of a folding Rule, ſuch as Carpenters and other Workmen uſe; which Rule is in its general Conſtruction very much like a *Sector*, which alſo may ſerve you for the ſame Purpoſe.

The ſecond Way of forming Statues is thus: According to the Size or Form of the intended Body, they with a Number of ſuch Cartouches Fig. 189. or Boxes I gave in *Fig.* 189, make the one half of the Statue; that is, that Part which comprehends the Breaſt, the Back, the Belly, and others of the Inferior Members. Then with Boxes or Caſes of ſmaller Sizes, they form the Neck, the Head, the Arms, the Thighs, the Hands, the Feet, and all the Extremities of the Body; bending and faſhioning them at pleaſure upon Wooden Balls filled with a *ſlow Compoſition*, and piercing them in two Places, juſt as the Fold or Curvature of the Limb requires: Into theſe little Borings they ſtick little Fuzes to give Admiſſion to the Fire as faſt as the Balls conceive it. All theſe Articles and Circumſtances being duly obſerved, and cultivated, the Statue is covered over with ſome Cloathing of Cloth, or Canvaſs, or Silk, or (if you will) Paper, cut out, ſewed together, coloured, and diverſified, juſt as the *Engineer* ſhall think proper. To the Head of it, is added a Paſteboard Mask, and Shooes, and Gloves of the ſame, are put upon its Hands and Feet; in ſhort, they endeavour as much as poſſible, that none of the Inſide may appear in Sight. The Head of the Figure is commonly a Ball filled with *ſlow Compoſition*; which Ball is ſometimes bored in ſeveral Places, and eſpecially when they would have a ſmall *Fire Rain*, or long *Rays* to dart forth as from *Running Balls*. This I have repreſented Fig. 202. to you in the Ball upon which the *Statue of Fortune* is fixed in *Fig.* 202.

But I muſt here ſtrictly caution our *Pyroboliſt* to take the utmoſt Care in joining and aſſembling the ſeveral Members of the Body, that they may be in no danger of being diſperſed by the Violence of the Fire, and that the firſt that are enkindled may not tear away thoſe which have

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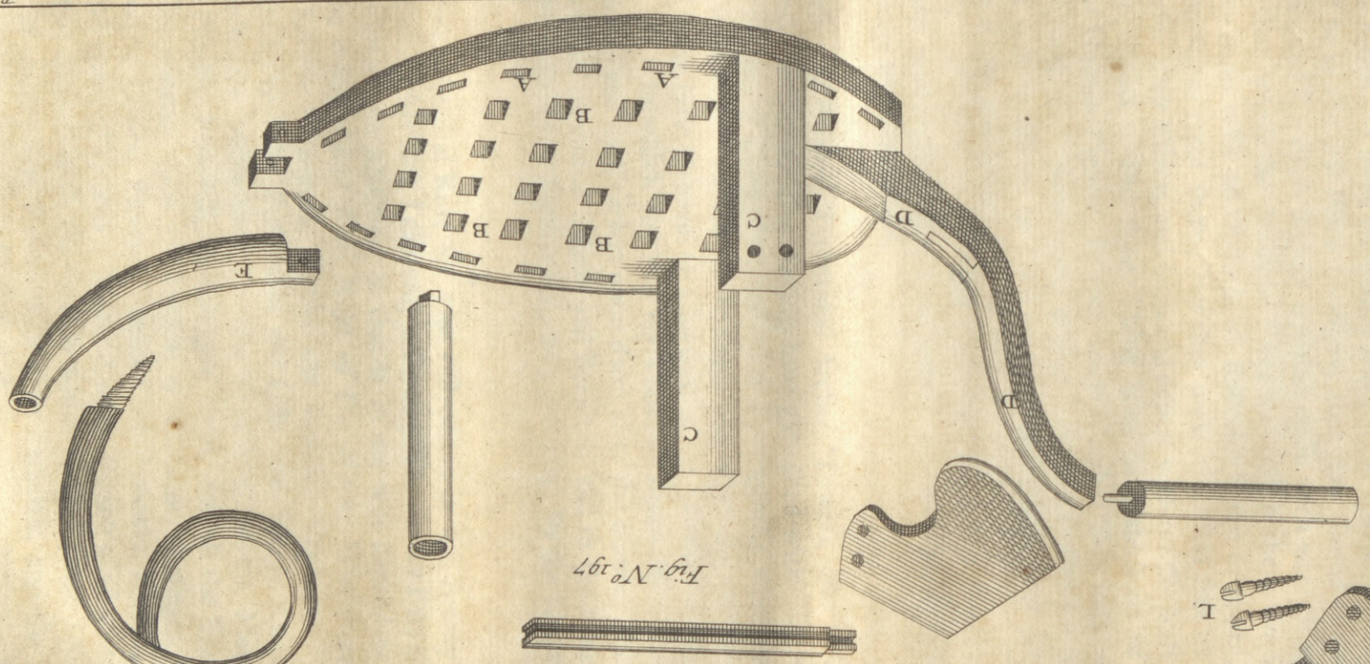

Fig. N°. 197

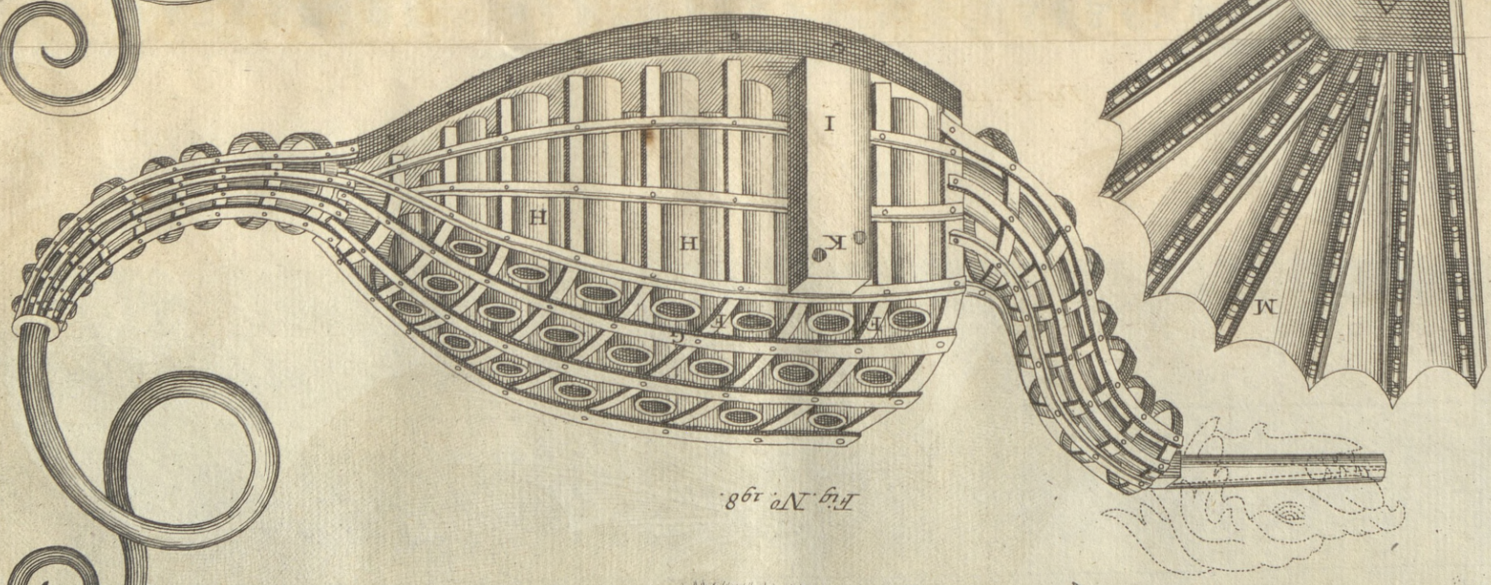

Fig. N°. 198.

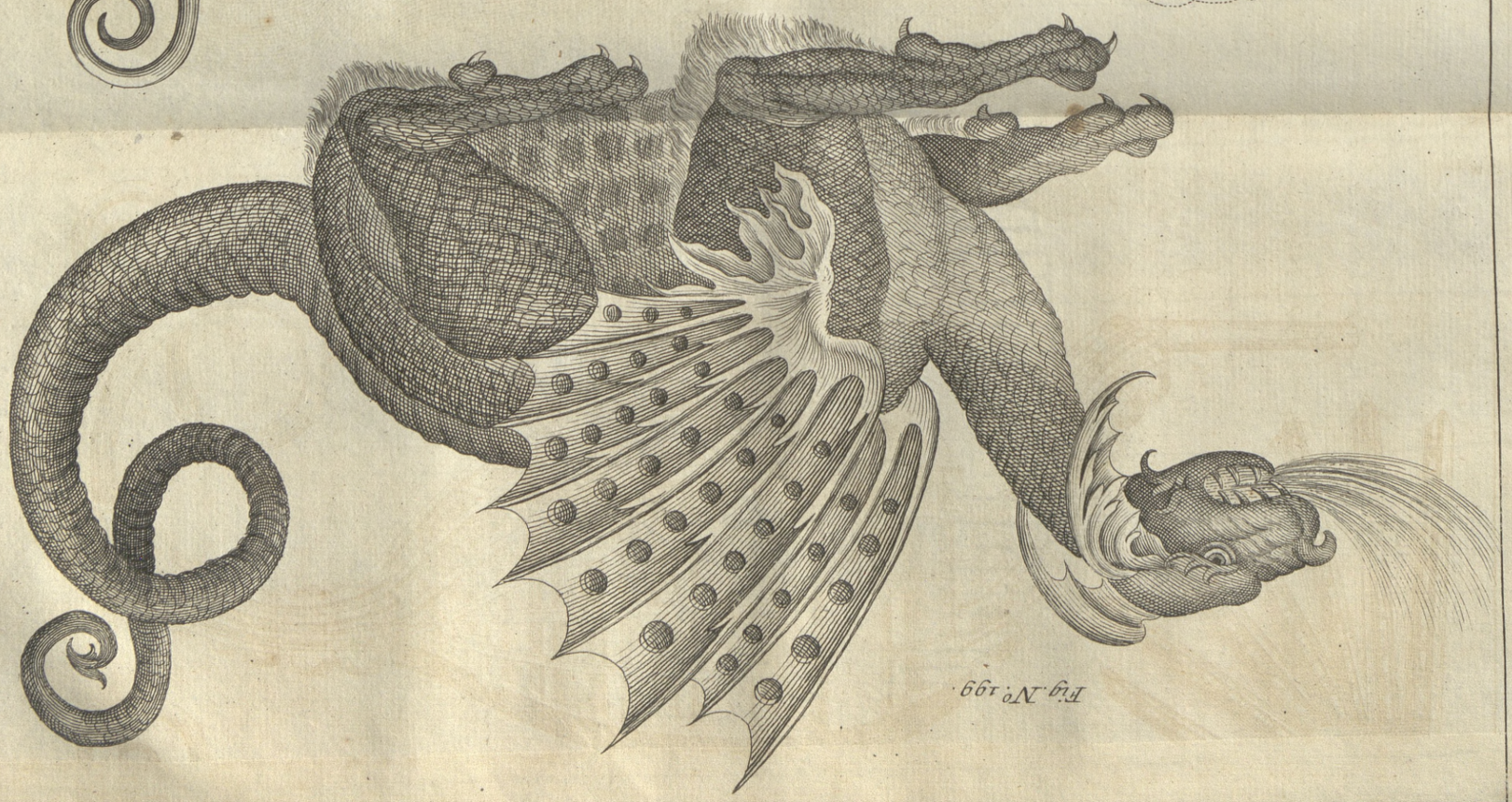

Fig. N°. 199.

not yet been conſumed; for otherwiſe your Work will have a far other Effect than you expected.

VII.

Whatever Animals you would repreſent, ſhall be cloathed in their own natural Skins, that approaching thereby the nearer to Nature, they may the better and more effectually deceive the Spectators. However; it will be in the firſt Place neceſſary, that you ſhould cut theſe Skins to pieces, and ſew them ſlightly together again with wide Stitches; to the end, that when the Artificial Fires incloſed in them would fly out, they may meet with no Obſtacle of ſufficient Force to retard, divert their Courſe, or repel them; but that with an Action free as Air, they may purſue their Effects, and burn and depart without the leaſt Reſtraint or Oppoſition. The ſame Thing is to be underſtood of the Cloathings of Human Figures, be they made of what they will, whether Silk or Cloth, *&c.* particularly if your Fires are ſo diſpoſed withinſide as not only to riſe up or burn out perpendicularly, but alſo obliquely to the Right and Left.

VIII.

Water-Globes muſt in like manner be covered over with Scales of Fiſh, and the Plumage of Water-Fowl.

IX.

The Coverings of Palaces, Triumphal Arches, Towers, *&c.* if they conſiſt of Planks or Boards (after having been garniſhed withinſide with ſeveral Sorts of Caſes of *Compoſition*, and other *Pyrotechnical Works)* muſt be armed on the Outſide with Iron, or Paper *Crackers*; for which reaſon you ſhall make little Grooves or Channels in the Interior Surface of your Planks, *&c.* in which you may lay Trains of *Quick-Match*, or of ſome *Compoſition*, and fix *Crackers* upon them after the manner I taught you above, when I treated of Shields and Bucklers, and in the ſame Order, as may be obſerved in *Figures* 200, 202 and 204, by the Letters B, C and F. Fig. 200, 202, 204.

X.

To give you a general Rule for your Inſtruction in the Beauty and manual Practice of this *Art*, I can only tell you; That every Part either within or without your Machine, or that is in any wiſe dependent upon it, muſt be compoſed of ſome Kind of *Fire-Work:* Wherefore all the Beams, Rafters, Tranſums, Planks and Boards; Capitals of Columns (if there be any) the *Paraſtatæ*, the Liſts, the Flutes, Cornices, Friezes, Architraves, Modillions, Dentils, Trygliphs, Drops, Metops; in ſhort, the Plinths, Pedeſtals, Apophyges, Baſes, and all the Enrichments and Decorations, ſuch as Wreaths or Garlands, Foliages, Feſtoons, Fruitages, Leaves, Flowers, Antics, Coat-Armours, Shields, *&c.* muſt all conſiſt either of *Crackers*, *Stars*, *Sparks*, *Rockets* of all Sorts, or of little *Hobbits* charged with the various Kinds of *Fire-Balls*. As for the Manner of conſtructing Baſons with their Pedeſtals, and the Me-

thod of ordering the Steps of Fountains, and garniſhing them with *Rockets* or *Crackers*; it may be eaſily learned from the *Figures* diſtinguiſhed by C and D.

XI.

You muſt fix ſome of your *Iron Crackers* obliquely, and others perpendicularly to the Horizon, but their Vents or Fuzes ſhuſt be turned ſome Upwards, and others Downwards; ſome to the Right, and others to the Left: Thus will they be alternately and diverſly diſpoſed. You muſt take particular Care, that your double and triple *Crackers* be all fixed perpendicularly to the Horizon.

XII.

Now as no particular Sett of Things meets with Approbation from all Sorts of People; and ſince what pleaſes one diſguſts another; and in Conſideration that our Works are not deſigned to adminiſter Pleaſure to a few Perſons only; but are to undergo the rigorous Scrutiny and Examination of a Multitude, whoſe Taſtes it will be neceſſary for our *Pyrotechnician* to conſult (provided that the Bulk of his Spectators are of ſufficient Capacity, to judge aright of his Work; for otherwiſe it would be better to pleaſe a few Perſons of ſound Senſe and Knowledge than thouſands of the Ignorant and Vulgar.) I ſay, theſe Things conſidered; it will be very proper to intermix your *Crackers* with *Rockets* of ſeveral Sorts, and other *Pyrotechnical Inventions*, which from time to time, and at ſutable Intervals, may depart, fly up, and perform the Effects natural to them, thereby to increaſe the Diverſion, and avoid Scandal. Farthermore, if the *Engineer* thinks proper, or if it be the Will of the Perſon or Perſons he is employed by, to have ſeveral Fires break out at once, and to have the Diſcharge of *Crackers* more frequent than is cuſtomary; there ſhall be a good Number of Vents made in ſeveral Parts of the Machine, through which the Fire may be introduced whenever you pleaſe into the Works contained in the Body of the Fabric: For there are thoſe who uſually make but one Vent, and that, upon the Top of the whole Pile; by which means the whole Body of it is conſumed ſucceſſively, and by Degrees: But this muſt be left to the *Engineer*. This way of giving Fire to our Machines, muſt be owned to be very Artificial; but the other is more certain and leſs dangerous.

XIII.

Fires of various Colours are held in great Eſteem with regard to theſe Works; as if, for Example, you would repreſent a *Rainbow*, an *Infernal* or *Gloomy Fire*, *Water*, *Stars*, and ſuch like: But having handled this when we ſpoke of *Sky-Rockets*, our *Pyrotechnician* may turn back to that Part of our *Work*, where he will meet with ſufficient Inſtruction upon this Head. Again; you muſt contrive to have imitative Lightning, or ſome extraordinary Flaſhes or Glares, which will vaniſh as ſoon as ſeen. This may be eaſily done with a little yellow *Amber* or *Colophone*, *Gum Juniper* or *Ship Pitch* well pulverized or mealed.

XIV. If

XIV.

If the *Engineer* by his *Artificial Fountains* would repreſent a Croſs, a Star, a ſmall Rain, a Rainbow, or any Thing elſe of that Nature, he muſt get Clay Pipes made; (for our *Compoſitions*, however *ſlow* they may be, will melt any ſort of Metal by means of the *Sulphur*, *Salt-peter*, and other hot and violent Ingredients they are compounded of;) theſe Pipes may be made after the ſame Form and Faſhion, as when applied by *Water-Engineers* to perform the like Effects. They ſhall be made with a wide hollow Foot at Bottom, that they may conveniently ſtop up or cover the Orifices of *Caſes* or *Globes:* The *Compoſitions* theſe are filled with muſt be very *ſlow*, and mixed with certain Portions of Things which produce Fires of various Colours, and Sparks in abundance. Again, all the Pipes faſhioned after the Manner we have here ſpecified, muſt be alſo filled with as much of the ſame *Compoſitions* as they can contain.

XV.

The utmoſt Diligence muſt be applied in conducting the Trains, in fixing and adjuſting the *Rockets* and *Crackers*, and in the diſpoſing of all the other Works; in which conſiſts the whole Beauty of the Fabric, and in the Execution of theſe Articles the *Engineer* will have an Opportunity of diſplaying his Skill; in ſhort, it is upon his prudent Management of theſe Circumſtances that his Welfare and Life depend; and not only his own, but thoſe alſo of his Workmen and Spectators: For to ſay the plain truth of the matter, I have ſeen many *Fire-works*; but Few, that ſucceeded ſo well as might be wiſhed; becauſe the greateſt Part of them catching univerſally and inſtantly in a Blaze, have ſometimes been the Death of ſeveral, and ſpoiled many unfortunate Perſons, who (far from expecting ſuch calamitous Accidents) came to be diverted. Now the induſtrious *Pyroboliſt* will avoid the Danger of theſe ſo-much-to-be-dreaded Diſaſters, if he be particularly cautious to fill all his little Pipes, Fuzes, or Trains of Communication, with a *Compoſition* whoſe Sloth he has been aſſured of, by repeated Experiments. I approve perfectly well of *Quick-Match*, that has been throughly dried and duly wrought; and this I advance from my own Experience, having often uſed it myſelf with Succeſs: But whether you prefer *Quick Match*, or whether you think that *Slow Compoſition* will anſwer your Purpoſe the beſt; I ſay, which ſoever of them you chooſe, it ſhall be laid in Channels or Pipes of Copper: For if they be made of Wood they are preſently burnt, or elſe they ſplit; if they be made or lined with Lead, they melt with the leaſt Heat; if made of Iron they inſtantly grow Red-hot, and ſet fire to the wooden Work, Cloth, Paper, *&c.* and thereby ruin your whole Undertaking; but Copper Tubes or Pipes are exempt from all the abovementioned Accidents, from the natural Hardneſs, or Solidity of their Metal. Theſe Pipes or Tubes ſhall be well reinforced with the Sinews of Beaſts ſteeped in Glue,

Glue, in which has been previouſly diſſolved a little *Allum Plume*. All theſe Pipes muſt be laid in Grooves wrought in the Wooden-work of the Machine, or they may be fixed naked from one Fire to another.

The Junctures or Joints of them muſt be well luted with Clay, or elſe faſtned together with Sinews well ſteeped in Glue, ſo that the Fire may have no Excurſion through them. Again; you muſt make ſeveral Vents or breathing Holes through which the Fire may correſpond with the outward Air; for if it be kept cloſe it will either be ſuffocated, or burſt the Pipe which confines it. All theſe Vents ſhall be made with ſuch Care and Exactneſs, that they may not only let out the Fire clear of the other Works, but alſo (if they are hid in the Planking, or if they are fixed on the Outſide) ſet fire to the *Rockets* and *Crackers*, in conſideration that ſeveral other Parts of the Machine will be conſumed whilſt the *Rockets* and *Crackers* are diſmiſſed and diſcharged: But however as theſe Vents will not be ſufficient to let out the Filth generated from the Smoke and impure Particles of your *Compoſition* or your *Quick-match*, which will clog up the Train-Pipes (if we may ſo call them) you may at convenient Diſtances make Spouts, Gutters, or pretty large Apertures, through which all the *Fæces* may be diſcharged, and at the ſame time give Admiſſion to the Air: here alſo you muſt take care that the Fiery Filth thus expelled, does not interfere with any of your other Fireworks, but that it may be carried clear off by pretty long Spouts.

Above all Things you muſt be cautious not to ſuffer any Match or Fire near your Machine, that you may not be liable to ſuch Diſaſters as might ariſe from their Proximity. Upon the whole I apprehend, that I need not trouble myſelf with giving you particular Inſtructions for conducting your Trains or Fuzes; and indeed no particular Rule can be laid down to guide you in it; becauſe of the Variety of Poſtures, Situations, and Contrivances of our Pieces of *Machinery*. It is to be hoped that whoſoever attempts any Performances in this Tickliſh Art, will by a due attention to the Rules with which we have furniſhed him in this Work, be able to avoid all Blunders and Miſtakes; add to which, that our *Pyrotechnic* Novice may gather ſufficient Direction in this Matter from the *Orthographic* and *Scenographic Figures* which we have with ſo much Care and Induſtry traced out.

XVI.

The laſt Thing I would recommend to you is, ſo to contrive, as to have none but ſober, conſiderate, and virtuous Men concerned in carrying on the Work under you; and never to admit any vile, prophane Men into your Service: For ſince we muſt not hope for Succeſs in our moſt trivial and minute Undertakings without the Concurrence of Heaven; you may readily imagine, That you will ſtand in the greateſt need of the *Celeſtial Protection*, when encompaſſed on all Sides with

Fig. N.º 200.

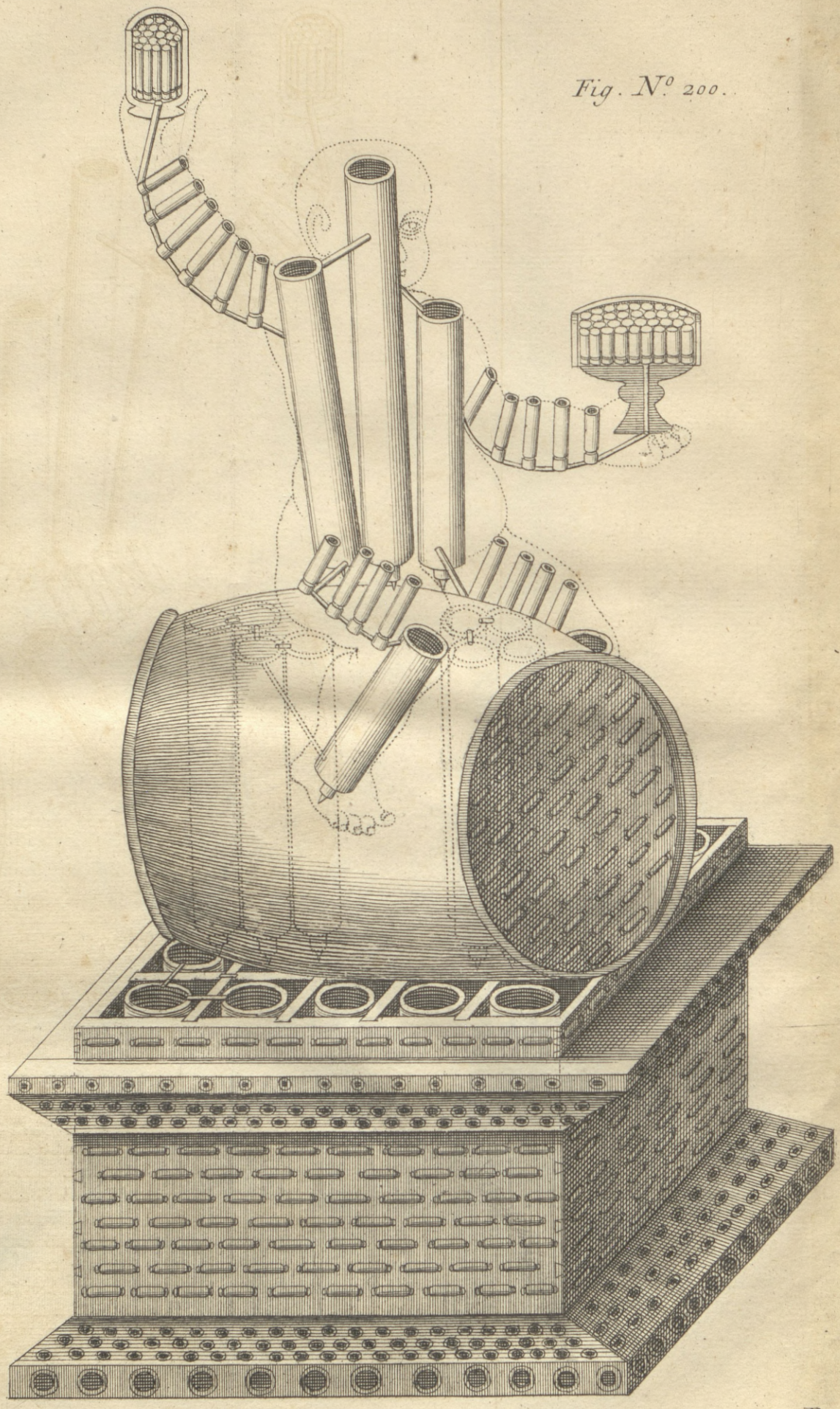

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Fig. N°. 201.
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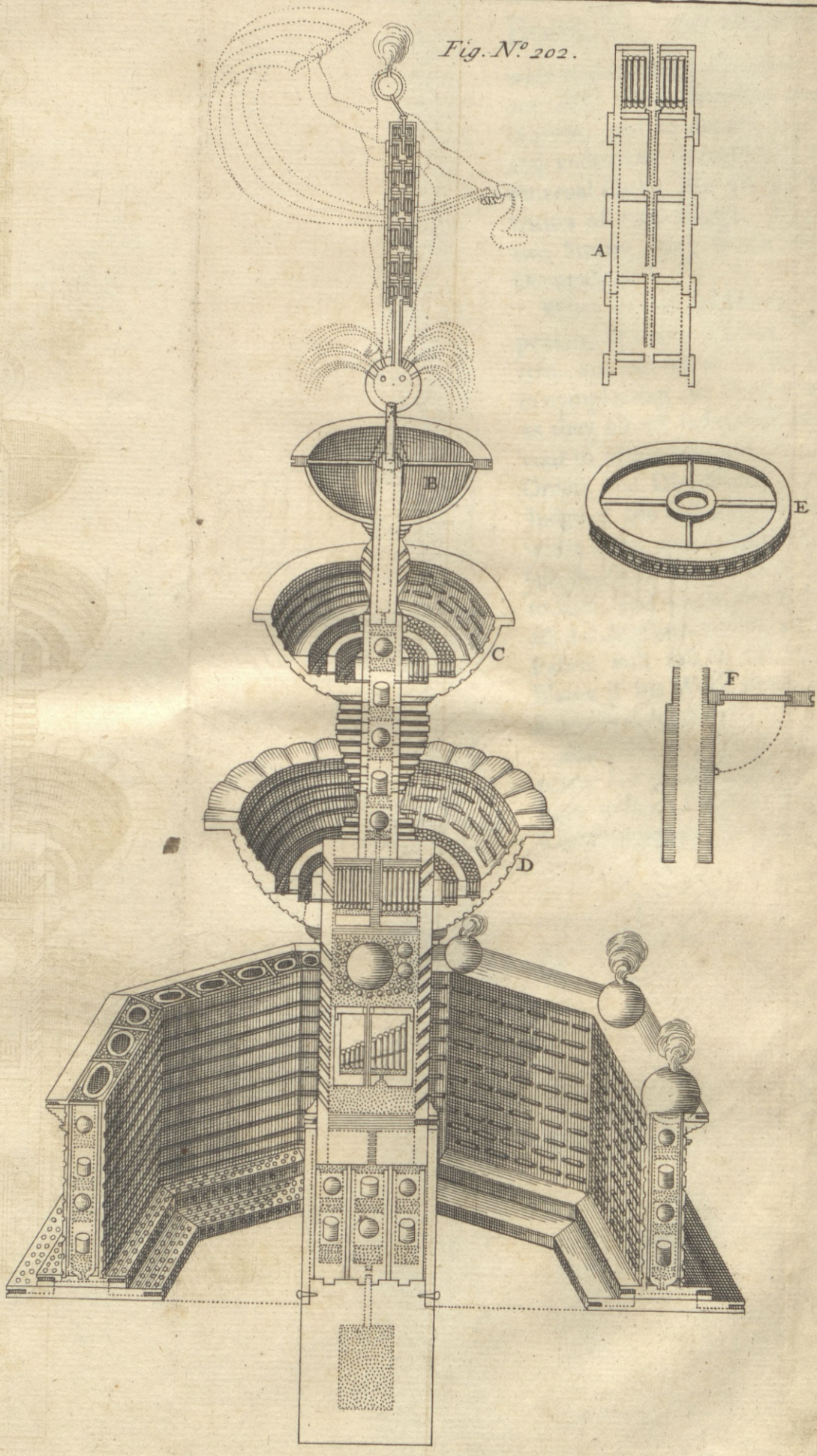

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with extraordinary Dangers, as all thoſe are, who make Profeſſion of our *Art*: And therefore ought you to have a continual Eye upon Heaven, and to depend upon God for your Safeguard and Protection; and endeavour to render yourſelf a deſerving Object of his Mercy and Paternal Care: For the accidental Shock of two Stones, the haſty Attrition of two Strings, nay the very impetuous Rubbing together of two Straws, may be the Death of you, when buſied in ſuch perilous Occupations.

What I have farther to ſay here, is addreſſed to the Smiths, Carpenters, Braſiers, Joiners, Turners, Maſons, Carvers, Plaſterers, Painters, and the whole Tribe of Workmen, whoſe Aſſiſtance is required in compleating our *Pyrotechnic Fabrics*. To theſe I muſt recommend; as they all act in Subordination to the *Fire-Engineer*, That they endeavour to pleaſe him and do him Juſtice, by obſerving to execute all his Orders and Directions. In ſhort, the *Engineer* ought to be a perfect Judge of the Capacity of his Workmen, and the Value of their Work when done, and conſequently know how to accept the Good, and reject the Bad; for whatever Misfortunes happen, they will all be imputed to him, and not to the Workmen he employed; and on the other Hand, all the Applauſe reſulting from the Succeſsful Conſtruction of the whole Fabric will fall to his Share. Thus muſt he expect to ſuffer all the Blame if his Work demerits it, or to bear away all the Praiſe if it deſerves Approbation.

And now having ſet the laſt Hand to our *Recreative Fireworks*, after a pretty Long Diſſertation on them, (perhaps more ſo than ſome could have wiſhed) I ſhall proceed to the *Second Part of this Book*, in which I ſhall entertain you with *Artificial Military Fires*.

PART II. *of this* BOOK.

Which TREATS of

Serious *or* Military FIREWORKS,

Whether *Fixed*, or *Projectile*.

CHAP. I.

Of Fire Ollæ *or Pots of all Sorts*, Powder Flasks, Bottles, Cheſts, *&c.*

OF all the *Pyrotechnic Defenſive Works*, with which I propoſe to entertain you, in the *Second Part* of this *Fifth Book*; I ſhall firſt preſent you with the ſeveral Sorts of *Fire-Pots*, *Flasks*, *Bottles*, and *Cheſts*, &c. Theſe I ſhall begin with; becauſe they are more ſimple in their Conſtruction, than the other Things which are to follow them; and I ſhall reduce them within the Bounds of this Chaptet, becauſe they are in general prepared after one Way, ſaving ſome Particulars which are peculiar to each of them apart, which Diverſity becomes natural or neceſſary to them from the Variety of their Figures and Sizes. I ſhall then inſtruct you in the ſeveral Methods of filling and charging three certain ſmall Veſſels.

METHOD I.

In the Firſt Place; Pour *Quick-Lime* finely mealed into ſome Veſſel, till one Third of it be filled; which done, fill it up to the Brim with good *Corn Powder*, and cover it with ſtrong Paper, or a wooden Lid; and over that with a pitched Cloth. You are to tye on Ends of Match to the Neck and Ears or Handles of your *Pot*, if it be made of Clay, as you may obſerve in *Fig.* 206. Your Veſſel being thus ordered, and having

Fig. 206.

having lighted the Match at both Ends, it ſhall be thrown amongſt the Enemy from ſome Eminence; as for Example, from the Top of a Rampart, or a Wall; or from the *Baſtions* of any Fortreſs into the *Foſſé* or *Moat*, or to any of the neareſt Places if it be delivered by Hand: But it muſt be projected from proper *Machines*, if you would ſend it to Diſtances, ſuch as the Lines or Works of the Enemy. On the other ſide, theſe Veſſels may be thrown by the Beſiegers into the Place beſieged; and they may likewiſe ſerve in Sea Fights, with great Diſadvantage to the Enemy and their Ships; for as ſoon as theſe fall upon a Ship's Deck, or meet with any hard Subſtance, they will never fail to break and fly in Pieces; upon which the *Powder* will be ſpilt, and ſcattered abroad, and the Match falling amongſt it, it cannot avoid *Accenſion*; and will accordingly break out with ſo terrible a Flaſh, as muſt ſpoil and deſtroy many of the Enemy, and perhaps burn the Ship itſelf: Not only that; but the *Powder* thus taking Fire it will at the ſame time blow up the mealed *Quick-Lime*, which riſing like a Cloud of Duſt, will be inſupportable to thoſe who are wrapp'd up in it. Sometimes inſtead of *Quick-Lime* you may uſe the Aſhes of Oak or Elm, provided they are well ſearced and reduced to an impalpable Meal.

METHOD II.

Sometimes they prepare Veſſels either of Glaſs or Earth with long Necks, (the Hollow of which is about an Inch in Diameter,) and bearing a near Reſemblance to the *Matraſſes*, *Retorts*, and ſuch like Veſſels in uſe with *Chymiſts:* The Body or Belly of theſe is filled with *Corn Powder*, to which are added certain Portions of *Mercury Sublimate*, and *Bole-Armoniac:* Sometimes alſo it is interſperſed with Scraps of Iron. The long Neck is to be filled with a *Slow Compoſition*: which being fired you may throw theſe Veſſels where you pleaſe.

METHOD III.

If it happens that the Veſſel is pretty large, and has a wide Mouth; for example, of 3 or 4 Inches in Breadth, or thereabouts; your *Corn Powder* ſhall be interſperſed with *Crackers*, either ſingle, double, or farther multiplied as you ſhall think proper: Or inſtead of them, *Hand Grenado's* without Fuzes, and only filled quite up to the Vent with *Corn Powder*. The Veſſels No. 206 ſhew you both the one and the other of theſe; whereof the Firſt diſtinguiſhed by A has *Hand-Grenado's*, the Second by B, has *Iron Crackers*. Fig. 206.

METHOD

METHOD IV.

There are thoſe who fill theſe Veſſels with very violent *Compoſitions*, and ſuch as are ſo obſtinately outrageous as not to be ſuffocated by any Means. We have already given you ſome *Compoſitions* of this Nature. Thoſe which we ordered for *Fire Rain* may ſerve this Purpoſe very well; but particularly ſuch as we communicated for making the *Grecian Fire*; for that was incloſed in ſuch Veſſels as theſe, as we have elſewhere ſhewn. However, notwithſtanding the ſeveral violent Fires I formerly gave you, I ſhall here preſent you with ſome others which are particularly calculated for this Service, and which are in Eſteem with the *Pyrotechnicians* of our Days. The Firſt, according to *Fioravantus:* Take of the *Varniſh* uſed in gilding of Leather 10 ℔; of *Sulphur Vivum* 6 ℔; of *Oil* of *Roſin* 2 ℔; of *Saltpeter* ℔ ſs; of *Olibanum* one ℔; of *Camphire* 6 ℥; and of the beſt *Brandy* 14 ℥: Put them all into a Veſſel, and mix them well together over a ſlow Fire; and being melted, add ſome Tow to them, and let it ſteep. This being put into Pots, will produce a Fire that will be inextinguiſhable, whereſoever it be thrown.

Uſanus in the third Treatiſe of his *Artillery*, *Chap.* XX, gives us the following: Take of *Gun-powder*, *Sulphur*, *Saltpeter*, and *Sal Armoniac*, of each ℔ ſs; of *Camphire* 2 ℥; meal them all finely, and paſs them through a Searce; which done, add to them a Pinch of common *Salt*. Put all theſe into a Braſs or glazed Earthen Veſſel, and pour *Oil* of *Olives* upon them, or *Oil* of *Petrol*, or of *Linſeed*, or of *Walnuts*; or elſe melted *Lard*; enough to give the Whole the Conſiſtence of a Paſte, or pretty thick Conſerve. Being all incorporated well together, take ſome of it out, and try how it burns, and ſee whether it can be eaſily ſuppreſſed by the Injection of Water; for if you find it too weak, you muſt add *Gun-powder* to it. Having brought it to the Pitch you would have it; fill Pots, Pitchers and ſuch like Earthen Veſſels with it.

In the ſame Veſſels you may add Lumps of that Liquified Stuff, which we mentioned in ſpeaking of the Preparation of *Fire-Rain*, wrapping them up in looſe *Quick Match:* Or you may uſe Balls of the Bigneſs of a large Walnut made of the following *Compoſition*; taking care to fill up the Interſtices between theſe Balls with a Mixture of *Corn* and *Meal Powder*. This *Compoſition* is thus: Take *Saltpeter* and *Gun-powder*, of each 2 ℔; of *Sulphur* ℔ ſs; of *Colophone* ℥ iiij; of *Camphire* ℥ ij; of *Sal-Armoniac* ℥ j. Incorporate them well together, and knead them with *Oil* of *Linſeed* or *Olives*; and in ſhort, make this *Compoſition* into Balls of the bigneſs of a large Walnut. Theſe Balls being once inflamed burn moſt outragiouſly; inſomuch that if they chance to fall upon a Ship's Deck, they will burn through and through it in the twinkling of an Eye; will ſet whatever they ſtick to in a Blaze, and accend and inflame thoſe Subſtances which are the leaſt ſuſcipient of Fire:

But

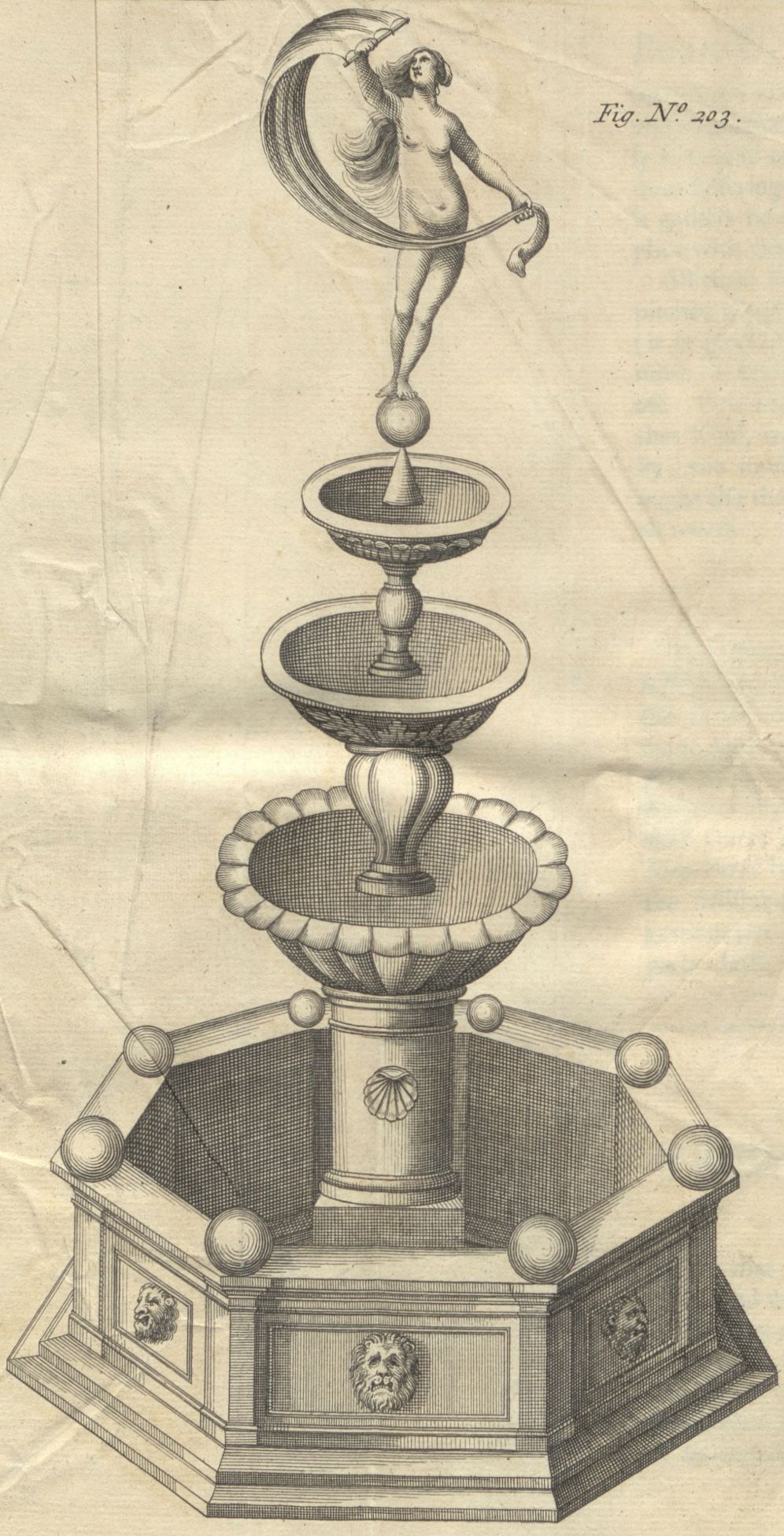


Fig. N.º 203.

V

P. F. Sculp.

But what I take to be their moſt extraordinary Property, is the Impoſſibility of ſuffocating or ſtifling them by any means; and it is particularly in vain to endeavour at a Suppreſſion of their Fire by Water; for far from ſuffering any Diminution of its Violence by the means of Water; it gathers new Strength, and rages the more obſtinately the more it is plied with that Liquid Adverſary.

All theſe Veſſels muſt be ſtopped up or covered cloſe with waxed or pitched Cloths, as we ſpecified above. To the Ears or Handles of them (it is perfectly neceſſary, that theſe Veſſels ſhould have Handles) you muſt tye Ends of *Match*, and ſecure them faſt, that they may not drop off. If it happens that your Pots have no Handles, nor any Thing of that Kind, nor even a Neck of ſufficient Length to tye your *Match* on by; you muſt give them a Coating of our *Pyrotechnic Cement*, or of ought elſe that is of a very tenacious Nature, and ſtick your *Match* in it all round.

ADVERTISEMENT.

That theſe *Ollæ* or *Pots* of *Fire*, and ſeveral other *Veſſels* filled with *Combuſtible Compoſitions*, were uſed by the Ancients, to ſet Fire to Buildings, *&c.* is not to be diſputed; if we rightly conſider the Teſtimony of ſo many Authors whom we quoted when we ſpoke of *Hand-Grenado's* and *Fire-Rain*. But it muſt be allowed, that all the *Fire-Veſſels* of the Ancients were but Trifles and Children's Play-Things, when compared with Ours; or at moſt, that they were but the Shadows of our Modern *Fire-Pots*; becauſe they wanted our *Thunder-imitating Gun-powder* by the Aſſiſtance of which we are enabled to cauſe ſuch frightful Flagrations; to burn and deſtroy the greateſt Part of our Adverſaries; and particularly, if to theſe *Pots* you add *Hand-Grenado's* or *Crackers*.

CHAP. II.

Of Fire-Crowns *and* Garlands, *which the* Germans *call* Pech, *and* Sturm Krantzen.

HE that would render himſelf Worthy of a Mural or Naval Crown, and who is ambitious of being honoured with one from the Hands of his King or Prince; I ſay, whoſoever is deſirous of being diſtinguiſhed by thoſe proud Marks and Badges, which are beſtowed on Merit and Virtue, muſt, the better to qualify himſelf, know how to manage our *Pyrotechnic Crowns*; he muſt prove them and put them in Execution, if he expects to ſee his Temples adorned with a Wreath of Laurel.

Our *Diadems* and *Garlands*, I muſt own, will burn, and oftentimes prick thoſe who handle them; but who knows not that Roſes are gathered amongſt Thorns? And that all our moſt perfect Happineſs, and moſt tranquile Contentment in this World, take Birth, in the midſt of the moſt pungent Sorrows, and a thouſand afflicting Difficulties, which perpetually oppoſe us in our Purſuits of what we would enjoy. No one ever yet obtained Glory, but by ſtruggling, and combating with Misfortunes and Labour: It is no ſmall *Encomium* upon a Soldier to ſay of him, *That he is both able and willing to endure Hardſhips.* This Acknowledgment is the natural Right of a true Soldier, and what he may lay juſt Claim to, whatever elſe he may ſtand in need of. Thus though the Man who is crowned with our *Fire-Garlands* will be grievouſly laden, yet at the ſame time he will be pompouſly adorned; if his Actions are levelled at nothing but pure Glory; if he contemns Difficulties, and bears with Heroic Conſtancy all thoſe Hardſhips which oppoſe his Acquiſition of the Prize he thirſts after. Now in this *Chapter* I mean to inform you of what Flowers and Ornaments our *Crowns* and *Garlands* are compoſed.

Get a long Bag made either of Flaxen or Hempen Cloth, of the Breadth of 4 or 6 Inches, and of the Length of 3 or 4 Foot; and fill it with one of the *Compoſitions* we gave for *Fire-Balls.* The following *Compoſitions* are purely for theſe *Garlands*, &c.

I.

Take of *Saltpeter* 3 ℔; of *Sulphur* one ℔; of *Powder* 2 ℔; and of Powder of *Glaſs* ℔ ſs.

II.

Take of *Saltpeter* 3 ℔; of *Sulphur* one ℔; of *Charcoal* ℔ ſs; of Powder of *Glaſs* ℥ iiij.

III.

Take of *Powder* 2 ℔; of *Saltpeter* 3 ℔; of *Colophone* ℔ ſs; meal them finely, and mix them well: Having filled your Bag with one of theſe *Compoſitions*, bend it round into a Circle; ſo that the two Ends may meet, which muſt be ſewed together: And for fear the Stitches ſhould give way, or be burned during the Combuſtion of your *Garland*, you ſhall clap an Iron Hoop within it, whoſe exterior Circumference is equal to the interior Circuit of the Bag. Upon this Hoop then muſt your rounded Bag be ſecurely laced, and faſtened with Interweavings and Knots at proper Diſtances from each other, in Imitation of what we ordered of the ſame Kind for *Fire-Balls.* Being thus adjuſted, you muſt thruſt *Iron Crackers* into it; which *Crackers* ſhall be well charged with *Powder* and *Ball*; and pointed at Bottom, that they may the more eaſily penetrate the *Compoſition*: Or you may diſpoſe of them, as may be remarked in *Fig.* 207 and 208.

Fig. 207, and 208.

Fig. 209. The third Sort of our *Crowns* you have in *Fig.* 209: This is only armed with bearded Iron Spikes; with intent that if it ſhould chance

to

to fall upon the Head of any Perſon, he may not be able to take hold on it, to throw it from him; but be obliged to burn alive, and from this ſort of Torment, which may be ſaid to be its natural Effect, it may juſtly enough be called the *Martyrizing Crown.*

Sometimes alſo theſe *Crowns* are adorned, or rather armed, with *Hand Grenado's*, of the bigneſs of an Iron Bullet of one or 2 Pounds Weight; but they muſt have Fuzes of the Length of 3 or 4 Fingers ſcrewed into their Orifices to keep them tight and firm upon the ſaid *Crowns* or *Garlands*, and for the ſame Purpoſe alſo muſt they be laced on with Iron Wire. You have the Repreſentation of this in *Fig.* 210. Fig. 210.

Theſe *Crowns* and *Garlands* are applied to the very ſame Uſes as the *Fire-Pots* and other *Veſſels* which we deſcribed to you in the foregoing *Chapter*: I ſhall only add to what I have ſaid, That you muſt take Care to make two or three Holes, through which to fire the included *Compoſition*; and being lighted and inflamed on all Sides, you may throw them where-ever you ſhall think proper.

CHAP. III.

Of Fire-Hoops *or* Artificial Spheres.

IF you have a right Idea of the manner of preparing the *Fire-Crowns* we juſt now ſpoke of; you will meet with no Difficulty in ordering *Artificial Spheres*, which are only compoſed of ſeveral Hoops or Rings within one another, and placed Croſs-wiſe. Prepare then three or four *Hoops* or *Crowns* (according to the Directions we gave you in the foregoing *Chapter,*) of ſuch Size and Proportion to each other, that they may go into, or be received into one another, from the greateſt of them to the leaſt; (that is) That the Interior Circumference of the Firſt, be exactly the Exterior Circumference of the Second, and the Interior Circumference of the Second, be exactly the Exterior Circumference of the Third, and ſo on. Being thus ordered, put them together, (*viz.*) the two Firſt, at Right-Angles to each other; and the two Smaller, at Right-Angles between themſelves, but at an Angle of 45 Degrees with reſpect to the two Greater; or if you have more than four Hoops, they ſhall be all ſo ordered as mutually to interſect each other at Acute Angles in the two Points which are Diametrically oppoſite. To theſe you may add others which may embrace them round, or be in a right Direction to the Firſt; but they ſhall be bound on with Copper or Iron Wire; for if you only faſten them with Marline, it will be preſently burnt; by which means your Work will fall to pieces, and yourſelf be baulked in your Expectations.

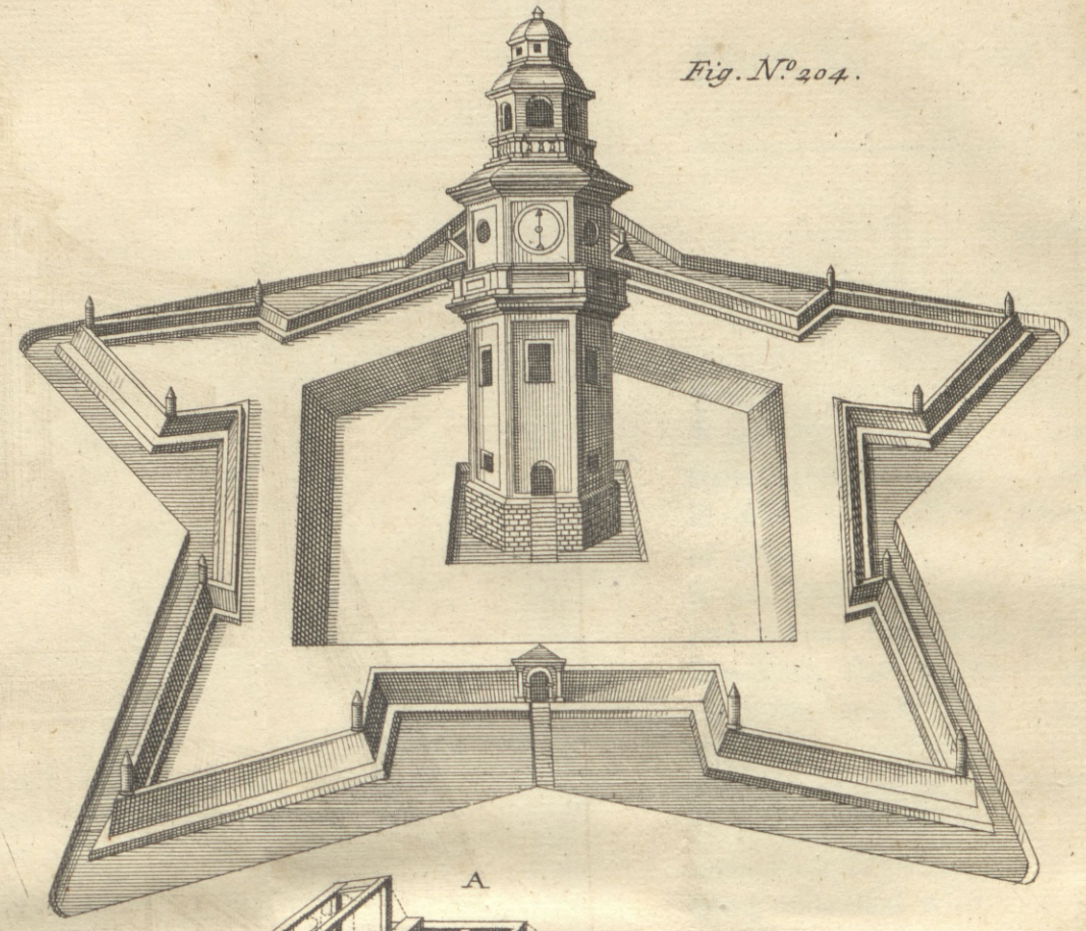
But

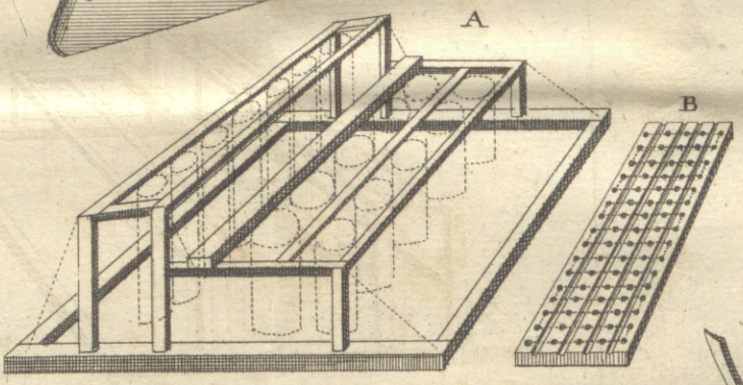
But by the way I muſt tell you, that it will be proper to have large Hoops for theſe *Spheres*; I mean, that they muſt be of ſeveral Foot in Circumference. The largeſt of them (for Example) ſhall be 15 Foot in its outward Circumference, and the reſt proportioned to it, as we ſaid above. It is alſo neceſſary to dip them all in Tar, and to pierce them with ſeveral Holes or Vents; that the whole Body of them may be fired at once, or in ſeveral Places, and conſequently, that it may be impoſſible for the Enemy to ſuffocate them, or diſengage themſelves from the frightful Diſorders theſe *Spheres* will introduce amongſt them. I have not given you any *Figure* of theſe; becauſe the Conſtruction of them may be eaſily gathered from what we have been ſaying, and by the Figures of our *Artificial Crowns*. As for that whoſe Repreſentation you
Fig. 211. have in *Fig.* 211, it differs from thoſe we have above-deſcribed: *Hanzelet* will have it conſtructed thus.

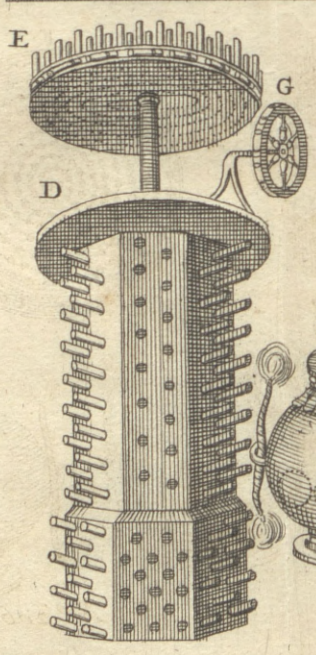
Take a Wooden Hoop, or (what will be better) an Iron one, juſt ſuch as Coopers uſe for binding their Cask: Daub it over with *Tar* mixed with *Gun-powder*, and take a Band or Slip of Cloth, whoſe Length muſt be equal the Circumference of the Hoop, and of the Breadth of three Inches: Wrap this Band round the Hoop, and fill it with a *Compoſition* made of one ℔ of *Powder*, one ℥ of *Sulphur*, and 3 ℔ of *Saltpeter*, ſprinkled over with a little *Oil* of *Petrol* or *Linſeed*, and interſperſed with Scraps of *Sulphur*. This done; ſew up your Cloth, and re-inforce it throughout with a Woulding of Marline, and pierce it in ſeveral Places with an Iron Point, filling all the Holes you pierce, with *Quick Match*. In ſhort, the whole exterior Surface of the Hoop ſhall be garniſhed with *Sulphur*, which muſt be wrapped round with *Tow*, excepting the Vents or Primings of *Quick Match* which muſt be left free and open. This is but half your Work; for you muſt prepare another Hoop after the very ſame manner (or ſeveral if you pleaſe) and having fix'd them in one another, you ſhall faſten them together with Wire, to prevent them from falling aſunder when thrown from any Eminence amongſt the Enemy. Being thus prepared and adjuſted, you muſt fire the *Quick Match* before-mentioned, and upon finding that your *Compoſition* is thoroughly accended, you may throw this *Sphere* where you pleaſe.

CHAP.

Fig. N.o 204.







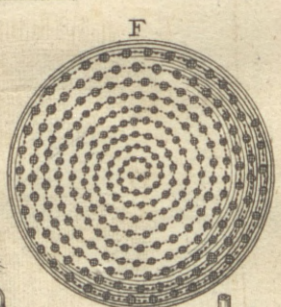


Fig. N.o 206.

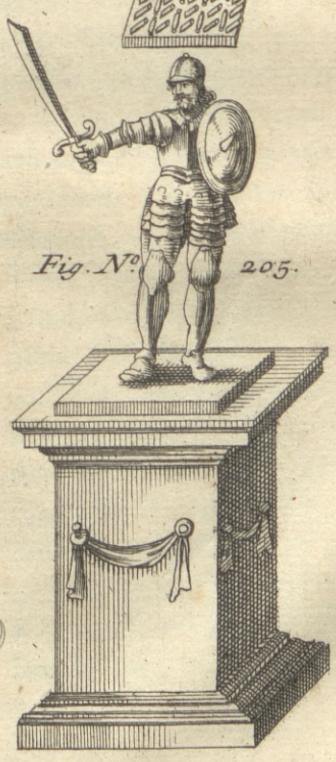


Fig. N.o 205.

W

P. F. Sculp.

CHAP. IV.

Of ARTIFICIAL CYLINDERS.

I Muſt here ſay once more what I have very often advanced already, namely, That we owe our Ingenuity in *Pyrotechnics* to Hints taken from former Inventions. I know that we improve a great many Things in our *Art*, which we pretend were unknown to the Ancients; many of which I am far from thinking they were wholly ignorant of; and it is not impoſſible, that former Ages might have had a more diſtinct and perfect Knowledge of ſome Things which we attribute to our Invention, than we have ourſelves, (ſaving what relates to *Gun-powder*) but which by a long Succeſſion of Time have been inſenſibly annihilated, and were never handed down to us. Now the Men of our Age are of ſuch a Turn, That having never ſo ſuperficially conſidered any of the Pieces of Antiquity, they dive preſently to the Bottom of them, and unravel them at once; and thereupon their Hearts being diſtended with Vanity, they fancy themſelves to be the very Inventors of Them. Whence it is, that they give them out, not only as their own, boaſt of them, and praiſe them up; but alſo arrogantly deſpiſe the Worthy and Ingenious of the Times paſt, who were in all probability at as much Trouble in the Cultivation of thoſe Things as we have been. For my part, I acknowledge that the earlier Ages of the World were productive of very great Men, and ſuch as were inſpired with an Inventive Spirit; but it muſt be at the ſame time allowed, that we may juſtly claim ſome ſhare of Applauſe and Approbation in Conjunction with them; inaſmuch as we have been able to make great Additions to their ingenious Practice; and inaſmuch as we know how to chooſe what is profitable to us from amongſt their Inventions, and ſeparate it from what is unuſeful to us, and after having cleaned it, and ſcowered off the Ruſt it had contracted by a Length of Years, have been at the Pains to reſtore it to its Original Luſtre. But I ſhall always ſtand firm in the Opinion which I have ſo often communicated in this *Work*, notwithſtanding any Arguments I can foreſee to convince of the contrary, (namely) that the Works of the Ancients were Lame and Imperfect through their Want of our *Gun-powder*; and that they conceived only the Shadows, and not the perfect and true Idea's of the admirable *Machines* of *War*. I formerly gave you ſome of their *Engines*, and after having compared them with ours, I made it evident to you, how much our Modern *Machines* ſurpaſs them in Dignity and Contrivance. I ſhall here again preſent you with ſeveral others: But before I do that, I ſhall make it appear by the Teſtimony of an-

cient Authors, that the *Pyrotechnic Cylinder* is a very antique Invention; which done, I ſhall ſhew you what Improvements the Moderns have tacked to it.

Let us firſt conſult *Vegetius* upon this Subject, and give Ear to what he ſays of theſe *Cylinders*. He ſpeaks thus of them in *Lib.* IV. *Cap.* viii. where he teaches us to conſtruct ſeveral *Machines* for the Defence of Walls. *They made prodigious Wheels of Green Wood, or* Cylinders *of the Bodies of vaſt Trees; (which they called Rollers) theſe they rounded very exactly that they might be the more rollable, and being trundled down Declivities, they ran over the Enemy and frighten'd their Horſes.* Let us now hear what *Ammianus Marcellinus* has to ſay of this Matter: *The greateſt part of thoſe who were concerned in the Aſſault, or made any Attempts to ſcale the Walls, were overwhelmed and buried under great Stones, vaſt pieces of Columns, and by* Cylinders *which were rolled down the Declivities and Taluds of the Walls.*

It appears then by theſe two Authors (not to quote any Thing from others) that the Ancients converted or applied the *Cylinder* to Warlike Uſes. But theſe could hurt none but the moſt Bold and Daring of the Beſiegers, who attempted to ſcale the Walls of the Beſieged; and only lamed them, broke their Ladders, and cruſhed the *Machines* or Perſons they happened to fall upon; leaving the Soldiers and Works, which were but a little diſtant from them, out of Danger. But our *Cylinders* are much more *Artificial*, and vaſtly more efficacious; for they not only by their Weight break and deſtroy whatever they fall upon, but alſo kill ſuch Perſons as are far diſtant from them, and throw down and demoliſh their *Machines* tho' pretty remote: For being hollowed, and then charged with Stones, Pebbles, Iron Bolts, and ſuch like; together with a good Quantity of *Gun-powder*; they are capable of doing incredible Miſchief. But before they are put in Execution they muſt be bound or reinforced with ſtrong Iron Rings, one at each Extremity of the *Cylinder*, and one at each End of the Charge of *Powder*. This is the
Fig. 212. firſt Sort of our *Cylinders*, which I have repreſented in *Fig.* 212. where the Letter A diſtinguiſhes a Wooden Stopple or Tompion for heading up the Orifices of it.

Fig. 213. You have the ſecond Sort in *Fig.* 213. It is armed all over with bearded Spikes; that it may not only be capable of Deſtruction by its Weight, by its Mortal Bowels, by its Flame and Fire; (all which it has in common with the Firſt) but alſo tear and wound thoſe with its Spikes, who are hardy enough to be Foremoſt in an Attack, or in mounting a Breach. This alſo muſt be reinforced at each End with a Subſtantial Iron Ring.

Fig. 214. The third Sort of *Cylinder*, which you have in *Fig.* 214, is yet more Artificial, and more cruelly adapted for Execution, than either of the Former; for the whole Capacity of it is filled with *Hand Grenado's* and *Crackers*, of ſeveral Sorts (ordered as uſual) the Interſtices of which

are

are filled up with *Gun-powder*. Now this *Cylinder* is commonly compoſed of two *Semi-Cylinders*, as may be conceived by the Profil A. The two Pieces of this *Cylinder* muſt be forelocked or wedged together, and that ſo cloſely, that no Air may have Admiſſion into the Body of it, whereby it will be conſequently obliged to burſt with the Greater Violence. This *Cylinder* muſt have a ſmall Wooden Fuze to correſpond with the *Powder*, which Fuze muſt be filled with one of the *Compoſitions* we formerly gave you for the Fuzes of all Sorts of *Grenado's*.

To conclude, I here give you a fourth *Cylinder*; of which the Ancients had ſome Knowledge, if we may believe *Salluſt*; for I find that he writes to this Effect in his *Remains*. *They rolled down the Declivities vaſt Pieces of Rocks and Beams mounted upon Axles, and armed with Spikes, or ſhort Darts, like the Military* Ericii, *or* Chevaux de Friſe. But, good God! to what a horrid Point of deſtructive Power have we brought this *Cylinder*, by means of our *Gun-powder*? For that ſpoken of by *Salluſt*, was no more to ours, than a Shadow is to a Subſtance. You have the Repreſentation of this in *Fig.* 215, and by the Conſtruction of it, I ſhall evince that I have not exceeded the Bounds of Truth in the Aſſertion I have here advanced, and ſhall ſhew you how far we have improved upon the antique *Cylinder* of this Kind: The following Deſcription of it is taken from *Hanzelet*. Fig. 215. "Get a *Cylinder* hollowed "or bored throughout the Middle to the Breadth of 2 or 3 Inches, like "our Recreative Caſes. The whole exterior Surface of it (excepting "its Baſes or Ends) ſhall be ſtuck or armed with long Iron Spikes, be- "tween which you muſt fix *Grenado's* of a moderate Size: The Fuzes "of theſe *Grenado's* muſt be of Iron, and not only ſcrewed into the "Vents of the *Grenado's*, but alſo into the *Cylinder*, (ſee *Fig.* A) by "which means they will be immoveably fixed: Again; theſe Fuzes "muſt be of ſuch Length, as to reach cloſe home to the *Compoſition* "contained in the Body of the *Cylinder*. The whole being thus or- "dered, ſhall be mounted upon two common Wheels, ſuch as thoſe of "a Chariot with their Axle-Trees, which muſt exactly fit the Orifi- "ces of the *Cylinder*, and be ſecurely ſtuck into them: Theſe Axles "ſhall be alſo bored throughout to the Breadth of an Inch or there- "abouts, which Borings muſt be filled with the uſual *Compoſitions* for "Fuzes. In fine, this furious Body (which for its admirable Conſtru- "ction and wonderful Effects might juſtly be ſtyled a *Machine)* ſhall be "pitched all over, and being mounted upon the Axles, and fired at "each End, may be rolled down amongſt the Enemy; there to per- "form ſuch Havoc, as could not be effected by a Thouſand of the "antique Sort." To tell you now, how that is poſſible, would be entirely ſuperfluous and needleſs, ſince any Perſon who has but the leaſt glimmering Inſight into our *Art*, will readily conceive it. And therefore not thinking it worth while, to dwell upon a Matter which

is

is ſo ſelf-evident, I ſhall proceed to the ſhort Remainder of this *Treatiſe.*

CHAP. V.

Of FIRE-SACKS.

THESE *Artificial Sacks* are applied to the ſame Uſes in the Defence of Places, when attacked, or attempted to be ſtormed or ſcaladed, as the *Cylinders* above-mentioned. They are ordered thus: Take a pretty thick Wooden Bar of ſeveral Feet in Length, and ſquare it, or convert it into a Parallelopiped, and let the two Ends of it be cut ſharp, or in the Form of a Pyramid. Towards the Ends of it, you ſhall bore two Holes, nearly interſecting each other at Right Angles; into which you muſt thruſt two Wooden Tree-Nails, ſhod or armed at each End
Fig. 216. with Iron, as may be ſeen in *Fig.* 216, by the Letter A. Upon this Bar you muſt tye a ſtrong Canvaſs Sack, which muſt be pretty wide; that it may contain a good Quantity of one of the *Compoſitions* we ordered for *Fire-Balls.* Having tied it faſt to the Bar by one of its Ends, fill it at the other with a proper *Compoſition*, and ram it and ſhake it down 'till it be as hard as what we directed when we ſpoke of the *Filling* of *Fire-Balls.* In ſhort, tar the whole Body of it over, and coat it with
Fig. 217. *Tow.* You have this in *Fig.* 217.

Fig. 218. The other *Sack*, which you ſee in *Fig.* 218, differs from the foregoing, in that its Bulk is uniform and equal from one End to the other; without ſwelling or bellying out, more in the Middle than at the Extremities; as may be perceived by the *Figure:* Add to which, that it has no Bar or Axle running through the Body of it, like the foregoing; but has only two ſmall Wooden Fuzes, fixed in each Mouth of the *Sack*, which are filled with a *ſlow Compoſition.* What we have here ſaid of the foregoing, together with the *Figures* we have referred to, will give you a perfect Idea of whatever relates to this. Theſe *Sacks* muſt be armed on the Outſide with *Iron Crackers.*

CHAP.

CHAP. VI.

Of ARTIFICIAL TUNS *and* BARRELS.

THAT *Tuns* and *Barrels*, as well as *Cylinders*, were uſed by the ancient *Greeks* and *Romans*, and ſeveral other Nations that flouriſhed with them, in the Defence of Places beſieged, may be gathered from what we are now going to communicate. Firſt then, † *Dio Caſſius* ſpeaking of *Tiberius*, who had beſieged a Place ſituated upon a Rock in *Denmark*, ſpeaks to this Effect. *The* ‡ Dalmatæ *galled them with Stones thrown from Slings, or rolled down by Hand; they likewiſe trundled down Wheels, and Cars full of Stones, together with Cheſts and Tuns, or Barrels made round after the Faſhion of the Country, all full of Pebbles.* *Hiero* alſo relates ſomething of this Nature, *They contrived to roll down Columns, Wheels, Chariots or Cars heavily laden, Veſſels full of Pebbles or wet Earth, like thoſe compoſed of Staves in which Oil, Wine, and ſuch like Liquors are kept.* *Ammianus* writes much to the ſame Purpoſe, || *Having boldly paſſed the* Foſſé *or Ditch over Hurdles, and gained the Foot of the Wall; they were immediately overwhelmed with vaſt Pieces of Stone, and Fragments of Columns, together with Tuns.* Now we can gather nothing from the Teſtimony of theſe Authors, and they prove nothing farther; than, that by ſuch like Contrivances, they cruſhed the Enemy to Pieces, and tore down their *Machines.* The Art of doing this is not ſo difficult, nor the Practice of it ſo obſcure; but that we might eaſily act it over again, if we thought it in any wiſe proper or neceſſary for the Defence of Places: But our *Gun-powder* has ſuggeſted far other Ways of defending ourſelves againſt thoſe, who would make any hurtful Attempt upon our Lives and Fortunes. We now prepare great Tuns, in the Center of which we fix a leſſer Veſſel or Cask full of *Powder*, or elſe a large Bomb; which we ſurround with Stones, Pebbles, Iron Bolts, *&c.* the Interſtices between which we fill with *Quick Lime.* The Veſſel being crammed after this Manner with as much as it can hold, is headed up, and well bound with Iron Hoops. In ſhort, having fix'd a Fuze in it to correſpond with the *Powder*, it is thrown down from the Ramparts amongſt the Enemy, where it does more Miſchief in an Inſtant, than all the *Machines* of the Ancients could do in ten Days.

Now the Havoc made by theſe Contrivances is ſo prodigious and frightful, that it is impoſſible for me to inculcate an Idea of it into you, and much leſs can I make you believe it, except you have ever hap-

† Dio. Caſſ. Lib. LVI. ‡ Now called *Sclavonians.* || Amm. Lib. XX.

pened to be in ſome ſort an Eye-Witneſs of it upon Warlike Occaſions. I for my part believe it is impoſſible for Human Wit to invent any Thing more efficacious than theſe, to cut off the Enemy when reſolved to carry you by Storm, to aſſuage the Violence of Attacks, and to caſt a Damp upon the moſt Reſolute and Courageous. We have a diſmal Example of the horrible Effects of theſe *Murthering Machines* in the Siege of *St. Andrews* in *Scotland*, which was inveſted in the Year of our Redemption 1524; at which Time one of theſe *Tuns*, filled with *Powder*, *Stones*, and *Iron Bolts*, being rolled down amongſt the Enemy, it wounded 600 of them at once, of which Number 321 remained Dead upon the Spot. We are informed of this by *Hierom Ruſſel*, an *Italian*, in his *Precepts of the Modern Arts of War*.

The Beſiegers might on the other hand throw ſuch *Veſſels* as theſe into the Places beſieged, (as alſo *Cylinders* and *Sacks)* if they had *Machines* proper for that Service, and particularly, if it was thought worth while to revive the *Baliſta* of Antiquity; which we ſhall not here enlarge upon, having ſpoken of it ſufficiently already.

Sometimes alſo theſe *Artificial Barrels* might be buried under Ground in any narrow Paſſage, or at the Entrance of any Place, or before the Gate of a Town; artfully fixing in them a Gun-lock with a good Flint, and having a long Line or Thread made faſt to the Trigger, to fire your *Gun-powder* or (if we may ſo expreſs ourſelves) ſpring your *Mine*, whenever you think proper; but the abovementioned Line muſt run under Ground, that it may not appear. If this Contrivance does not pleaſe you, you may (to be ſurer) put a Piece of lighted common *Match* into them, or ſome of our *Quick Match* twiſted, and ordered ſo as to burn till the Time you expect the Enemy to come upon that Place, in order to carry on their Attack: But you muſt ſo contrive, that the *Match* may breath the Air by a little Tunnel or Pipe, which muſt reach quite up to the Surface of the Ground; for fear the Coal of the *Match* ſhould be ſtifled by its own Aſhes, and conſequently baulk your Expectation. But I need not trouble myſelf with giving you any farther Advice upon this Subject: The skilful *Engineer* cannot be at a Loſs in managing this Matter with Succeſs.

We find that Neceſſity formerly ſuggeſted ſeveral Methods to the Beſieged, of not only breaking down and overſetting the *Machines* of the Aſſailants by the Weight of Stones, and other Ponderous Bodies, which they threw at them; but alſo of burning, and reducing them to Aſhes. And therefore amongſt other Inventions, they filled *Barrels* and *Tuns* with Combuſtible Things, and ſent them amongſt the Enemy's Works: Witneſs *Cæſar* in *Lib.* II. of the *Civil Wars*; who ſpeaking of the Siege of *Marſeilles*, ſays, " That finding the Beſieged very obſtinate in defend-
" ing themſelves, a *Muſculus* or Gallery was ordered to be built of 60
" Foot in Length, which had a ſloping Roof, covered with Tiles and
" Dirt to preſerve it from the Fires which might be thrown from the
" Walls;

" Walls; which Tiles and Dirt were covered with Hides to prevent " them from being torn away by Water which might be plaid upon " them; and the Hides were again covered with Cloths ſteeped " in Vinegar; in ſhort, the Body of this Gallery being made of vaſt " Timber ſecurely bound and clamp'd together with Iron, and the " whole of it compleated and fortified, it was moved upon Rollers cloſe " home to the Walls of the Beſieged. The Garriſon being aſtoniſhed " at this unexpected *Machine*, tore up the largeſt Stones that could be " raiſed with Crows, and threw them from their Walls upon the Gal- " lery; but it was ſo ſubſtantially built, that it received no Damage " from the Shocks of them, and what fell upon the Roof of it preſently " rolled off. He then ſays, That the Beſieged finding it was to no Pur- " poſe to make any farther Efforts to deſtroy the Gallery by Dint of " Weight, they bethought themſelves of another Stratagem; which " was, to fill Butts, Tuns, and ſuch like Veſſels with Pitch, and the " Heart of the Pine Tree, which they threw down all in a Flame up- " on the Gallery, but they immediately rolled off, and were eaſily re- " moved out of the way of doing Harm, by long Prongs or Pitch-forks. " In the mean time the Soldiers that were under the Covert of the Gal- " lery, looſened and pulled out the lowermoſt Stones of the Enemy's " Tower; and having taken out a good Parcel of them, and under- " mined it, a Part of it fell down with a ſudden Ruin."

The Thought of the Beſieged, in this Caſe, pleaſes me much; but I can by no means approve of the Effect of their *Artificial Tuns* and *Barrels*: They would have ſeen far other Execution performed by thoſe *Veſſels*, if they (unfortunate People!) had had any Knowledge of our *Gun-powder*; and from thence have hit upon a Preparation of their *Tuns* after our Modern Way. There is no Gallery how impenetrable ſoever it may appear, nor no Covert ſo ſtrong; no Hides, Planks, Blinds, nor Chandeleers ſo thick; no armed Men, tho' caſed in Steel to the very Teeth, that could bear the Shock of large Pebbles, Iron Bolts, or of the Shells which we uſually incloſe in theſe cruel *Machines*. Happy the Man who can avoid the Fury of them, or provide for his Safety by Flight, before the *Powder* in them catches Fire! Inſtead of amuſing himſelf with removing or thruſting our *Tuns* and *Barrels* away from the Works with Prongs.

I have given you the Repreſentations of our *Artificial Barrels* in *Fig.* 219, 220 and 221. But the laſt of them ſhews you two *Barrels* mounted upon one and the ſame Iron Axle: Theſe are not filled with Stones, but with *Grenado's*, *Crackers*, and *Corn Powder*, and are well bound with Iron Hoops, and ſtruck round with Steel Spikes. The Reaſon of their being armed after this Manner, is to defend them from the Attempts of certain Fool-hardy Perſons; who might venture to cut them in pieces with Axes, before the Fire can have penetrated to the *Powder* contained in the *Barrels*; for the ſame Reaſon it is, that they are mount-

Fig. 219, 220, 221.

ed

ed upon Iron Axles, and that the Wheels have Iron Straiks and Spoaks of the ſame Metal.

If theſe *Artificial Barrels* are not very large and heavy, they might ſerve in Sea-Fights, and be thrown into the Enemy's Ships, as well as *Fire-Pots*.

You muſt take great Care in fixing the Fuzes, for that is the main Point; and without being particularly cautious in ordering this Article, you run the Hazard of ſeeing your Work prove abortive.

In the two firſt of theſe *Figures*, the Letter A ſhews you a ſmall *Barrel*, and a *Grenado* or *Bomb* which are fixed in the Center of their reſpective *Barrels*. The reſt will be eaſily conceived by the *Figures*.

CHAP VII.

Of Pyrotechnic Flambeaus *or* Torches.

BY *Torches* we underſtand nothing more than certain *Brands* of *Artificial Fire*, which are thrown at Diſtances to fire the Enemy's Works: But to ſay the Truth, they are not much in Requeſt with us, and in ſhort, are grown quite out of Uſe. The Ancients practiſed them formerly with very good Succeſs, as we are told by *Vitruvius*. *The Divine* Cæſar *having his Army about the* Alps, *commanded the adjacent Towns to ſubmit themſelves, and yield him free Paſſage*, &c. *but there was a Caſtle near, which depending upon its natural Strength refuſed Obedience to the Summons: Upon which the Emperor commanded his Troops to advance towards it. This Caſtle was called* Larignum, *and before the Gate of it there was a Tower built of the beforementioned* Wood, *and compoſed of great Beams lying athwart each other (alternately) like a* Funeral Pile, *which being pretty high, they might from thence repel the Aſſailants with* † *Spears and Stones.* Cæſar *being informed that they had no other Weapons of Defence but Spears, which were too heavy to be thrown far from the Walls; he ordered little* Faſcines *or* Fagots *to be made, and thrown at the ſaid Tower, together with* Brands *or* Torches, *in order to ſet it on Fire. This was accordingly done, and whilſt the Heaps of* Faſcines *were in a Blaze, it ſeemed to every Body as if the Tower was really burned down to the Ground. But the Fire going out, and the Tower appearing whole and untouched,* Cæſar *was aſtoniſhed at it, and ordered his Army to advance up to it, and inſult it; upon which the Beſieged being ſtruck with Dread, they ſurrendered; and being asked what Wood it was that had thus been able to withſtand the Rage of Fire; they pointed at ſome of the Trees, which are in great Plenty in theſe Parts. This Wood is called* Larigna, *from whence the Caſtle itſelf is called* Larignum.

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† The *Latin* Word is *Sudes*, which were properly a kind of *Staves*.

Silius

Silius mentions theſe *Torches* in *Pugn. Canen.*

Ullum nec deſit teli genus, hi Sude pugnant,
Hi Pinu flagrante cient; hi pondere Pili.

In *Engliſh:*

They deal all miſſive Arms, fatal to Life;
Theſe with the flaming *Torch* provoke the Striſe,
Thoſe with the Javelin's Weight, *&c.*——

Lucan alſo in his *Pharſalia.*

——— *inde Sagittæ*
Inde Faces, & Saxa volant.

In *Engliſh:*

Thence *Stones*, thence *Brands* and *Arrows* fly.

Virgil alſo ſaith ſomewhere.

Jamque faces & ſaxa volant, furor arma miniſtrat.

In *Engliſh:*

And *Brands* and *Stones* in ratling Vollies fly;
And all the Ruſtic Arms that Fury can ſupply. *Dryden.*

Lipſius alſo in *Lib.* V. of his *Poliorceticon*, tells us how the Ancients were uſed to prepare theſe *Torches*, in theſe Terms: *The common* Torches *were thoſe which were made of Pine, Larch, and Fir: The ſmaller Sort of theſe they had for private Uſe in their Houſes; but with the larger Sort they fought, and threw them by hand at the Enemy's Works to ſet them on Fire.*

All this is Old: But our celebrated Annaliſt *Paulus Piaſecius* will furniſh us with an Example of a freſher Date; for ſpeaking of the Siege of *Wielkoluki* (a Town in *Muſcovy*) when it was inveſted and taken by *Stephen* King of *Poland*, he tells us; "That the aforeſaid Town being "ſurrounded by an *Enceint* compoſed of vaſt Bodies of Timber, upon "which Account, and for other Reaſons, it was found to be Proof a-"gainſt all Battery; and the King perceiving there was no Likelihood "of reducing the Place by any other Means than a Conflagration; he "had recourſe to Mines, which being ſprung, blew up a Rampart, and "ſet fire to the neighbouring Parts, which was extinguiſhed by the Di-"ligence of the *Moſcovites* beſieged; but that ſame Evening they con-"veyed *Brands* or *Torches* made of *Sulphur*, to the other Side of the "Town, which lying latent for ſeveral Hours, it was thought they "were extinguiſhed by the Dampneſs of the Ground: But a high Wind "ariſing towards Midnight, they flamed out a-freſh, and in a very lit-"tle time the Conflagration became general, and the whole Place was "laid in Aſhes; and above two Thirds of the Inhabitants were deſtroyed.

This is what I had to ſay of the Uſe and Effects of *Artificial Torches* and *Fire-brands*. I have nothing now to do, but to inſtruct you in the Preparation of them by the Rules of our *Art*; in caſe the Exigence of Affairs ſhould make it neceſſary for you to put them in Practice. Take then of *Sulphur* 8 Parts; of *Colophone* 2 Parts; of *Saltpeter* 4 Parts; of *Black Pitch* 1 Part; of *Wax* half a Part, and of *Turpentine* 1 Part. Having mixed theſe Ingredients well together in a glazed Earthen Pot, or in any Braſs Veſſel, melt them over a Fire; and being fuſed, throw into them ſome Old Linnen well waſhed and dried, or elſe Tow; but which ſoever of theſe you make choice of, you ſhall let it ſteep in the above-ſaid *Liquified Compoſition*; and taking it out whilſt it is warm, you muſt wrap it about long Sticks and bind it upon them with Iron or Lattin Wyre; but before you do this, you muſt drive Nails into your Sticks, that the Stuff may have the faſter Hold upon them. Your *Torches* being thus prepared you may light them, carry them, and throw them, where you pleaſe, and need not fear that either Wind or Rain will extinguiſh them; for on the contrary they will burn either upon or in Water with wonderful Rage to their utter Conſumption, and never can be ſuppreſſed by any other means than by being buried either in Sand or Aſhes.

CHAP. VIII.

Of FIRE-ARROWS *or* DARTS.

WHAT we here mean by *Fire-Arrows* and *Darts* where formerly called *Malleoli*, which ſome Authors confound with the Fagots and Torches, of which Number is *Nonius Marcellus*, who ſays: *The* Malleoli *are little Bundles of Broom, which being daubed over, or dipped in Pitch and fired, are thrown upon the Roofs of Buildings. Feſtus* is to the full as much miſtaken; ſays he: *Not only ſmall* Mallets *are called* Malleoli; *but thoſe alſo which are contrived to ſet fire to Buildings, and are made after the Faſhion of the Firſt.* But *Herodianus* explains himſelf much better when he ſpeaks of the Form of the *Malleoli*; tho' by the way he confounds them a little with the *Torches*; for he ſpeaks thus of them in *Lib* viii. where he gives an Account of the Siege of *Aix*. *But the* Machines *being advanced, they threw Torches at them, which were coated over with Pitch and Roſin, with a ſharp Point at the Ends of them; and which being lighted and thrown, ſtuck in the* Machines, *and eaſily burn'd them.* But of all the Authors I ever peruſed, I never met with any, that gave a more pertinent and rational Deſcription of them, than *Ammianus*, who writes to this Effect. † *The* Malleolus, *a kind of Arrow, is formed thus: It is an* Arrow *made of Cane, which between the Cane or Reed, and the*

† Ammian. Lib. XXIII.

Head

Head, or Point, is armed with an Iron ſeveral times doubled, and made like a Woman's Diſtaff: The Belly of it is finely hollowed, and it is laid open or pierced in ſeveral Places, and the hollow Trunk of it being filled with Combuſtible Matter, and fired, and ſhot eaſily from a large Bow (for if it be violently dimiſſed, the Fire of it will be extinguiſhed) it will burn whatever it ſticks in; and if Water be thrown upon it, it only ſerves to make it burn the fiercer, nor is there any means of ſuppreſſing it, but by the Superinjection of Duſt. The *Parentheſis* in this Quotation, in which he gives us to underſtand that a violent Agitation or a ſwift Flight would put out the Fire of the *Malleolus*, may give us an Idea, of how much it ſtood in need of our *Saltpeter*, and *Gun-powder*, whoſe Fire is Proof againſt all Attempts of Wind or violent Motion, and is ſo far from being impaired by either of them, that they only ſerve to irritate it the more. Again; *Vegetius* ſpeaks of the *Malleolus* almoſt to the ſame Purpoſe, namely, * *The* Malleoli *are like Arrows, and becauſe they carry Fire with them, they burn whatever they ſtick in. Æne:* a very Ancient Author calls them ſimply *Fire-Arrows* or *Darts*, as may be learned from *Iſaac Caſaubon*'s Tranſlation of him into Latin, where he renders them *Sagittæ igniferæ*; *Igniferous* or *Fiery Darts.*

This is what I had to ſay of the *Fire-Arrows* or *Darts* of the Ancients: It now ſtands me upon to give you ſome Account of Ours, and to teach you the Conſtruction and Preparation of them. You have three Sorts of them in *Figures* 222, 223, and 224. The Conſtruction of the firſt of them is thus. Make a little Bag or Purſe of the bigneſs of a Gooſe's or Swan's Egg, (which may be either longiſh or perfectly Round, as we formerly ſpecified with Relation to *Fire-Balls)* and fill it with a *Compoſition* made of 4 ℔ of purified *Saltpeter*; 1 ℔ of *Sulphur*; 1 ℔ of *Meal Powder*; ℔ ſs of *Camphire*; and ℔ ſs of *Colophone*. Or elſe: take 2 ℔ of *Saltpeter*; 2 ℔ of *Powder*; 1 ℔ of *Sulphur*; ℔ ſs of *Colophone*. Or this Third Compoſition which is as good as either of the Two former (*viz.*) 8 ℔ of *Saltpeter*; 6 ℔ of *Powder* and 4 ℔ of *Sulphur*. Having filled your Bag, bore an Hole thro' the Body of it; through which you muſt run a common Arrow or Dart, in ſuch Manner that all the Head or Iron may project out beyond it; then right under it drive a Wooden Peg athwart the Subſtance of the Arrow, or elſe ſtop it with two or three Nails that it may be immoveable, and in no danger of ſlipping down to the Feathers during the Flight of the Arrow, or when the Head of the Arrow ſtrikes againſt any Reſiſting Object. Fig. 222, 223, 224,

This done; lace it as you ſee in the *Figure*, and after the Manner we formerly ſpecified in ſpeaking of *Fire-Balls*; and coat it over with Pitch mixed with a little *Meal Powder*, and fire it by two ſmall Vents, near the Head of the *Arrow*, and ſhoot it where-ever you pleaſe with a common Bow or a Croſs-Bow.

* Veget. IV. Cap. xviii.

Of

Of the two other *Darts*; that which you ſee in *Fig.* 223 has a Concave Spherical Head, which uſually incloſes a *Hand-Grenado* or a *Fire-Ball.* In ſhort, the Third has a certain Box or Cartouch at the End of it, which is to be filled with one of thoſe *Compoſitions* we have given you in the preceding Part of this *Chapter.* The curious *Pyroboliſt* will find more of them in *Brechtelius*, *Part* II. *Chap.* III. In *Uſanus*, *Treatiſe* III. *Chap.* XXIII. In *Hanzelet*, Page 162. In *Jerome Ruſſel*, Page 48, and in ſeveral others who have amplified pretty prolixly upon this Head.

The Sequel of this *Chapter* ſhall illuſtrate the Uſe of *Fire-Darts*; which indeed are not greatly in Eſteem with us, and are, by ſome ſhallow-witted Perſons, held to be but aukward Contrivances for conveying Fire into any Place; but perhaps they are diſliked, becauſe there has been no Opportunity of uſing them in our Modern Sieges. However this be, we are informed by *Uſanus* (in *Treat.* III. of his *Artillery*, *Chap.* XXIII.) that the *Spaniards* found very ſucceſsful Service from them at the Sieges of *Ypres* and *Oſtend:* But were I to trace up the Hiſtory of theſe Weapons a little more remotely, I might produce an infinite Number of Examples to convince you that their Utility is admirable, and their Service by no means deſpicable. But not to ſwell out this *Chapter* with the copious Evidence I could introduce; I ſhall content myſelf with what *Martin Cromer* relates; who ſpeaking of the mighty Exploits of the *Poles* before the Town of *Choinice*, beſieged by King *Caſimir* in the Year 1466, N. S. writes thus: *Not long after our People* (meaning the *Poles) ſhot* Fire-Arrows *into the Town under the Covert of the Night, by which Means one Quarter of the Town was reduced to Aſhes, and all their Wheat deſtroyed.* You will find a thouſand Examples of this Kind in other Authors. But if ever they can be uſed to any very great Purpoſe, it muſt certainly be in Sea-Fights, to ſet Fire to the Enemy's Sails and Rigging, and eſpecially when they are headed with a ſharp Iron. In truth, I believe there can be no Weapon more pernicious upon ſuch Occaſions than theſe; for if they once ſtick in the Sails, *&c.* it will be very difficult to pull them out again; ſo that they muſt burn on without Interruption; and it would be impoſſible to extinguiſh them without clewing up the Sails; during which I leave you to judge, whether or no an Enemy might not eaſily board, and overpower a Ship's Company, which is under the confuſed Apprehenſions of ſeeing their Ship either burnt, or diſabled; for (pray) what is any Veſſel (which does not go with Oars) when ſtripped of her Sails, and in the midſt of an Engagement, but a Bird without Wings, a Man without Hands or Feet, or a Body without a Soul? In fine, all theſe *Arrows* may be ſhot into beſieged Places without being fired; thereby to ſurprize the Inhabitants the more, when they ſhall ſee ſuch ſudden and unexpected Ruin falling upon them: But to do this artfully, you muſt ſtick little pieces of lighted Sponge (ſuch as we taught you to prepare in *Book* II. *Chap.* XXVIII.) into the Vents of your little Bags of

Fig. N.° 207.

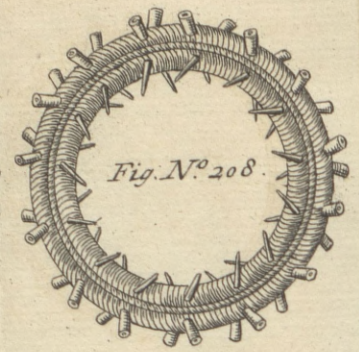
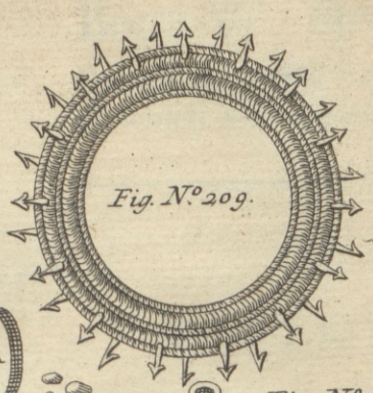


Fig. N.° 208.



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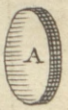


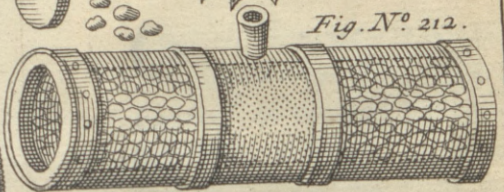


Fig. N.° 212.

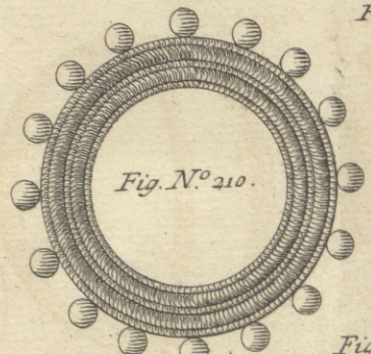


Fig. N.° 210.

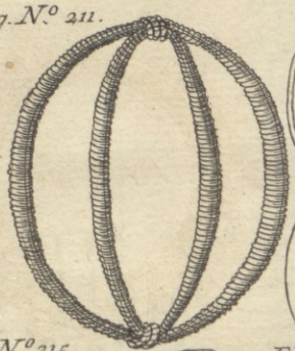


Fig. N.° 211.

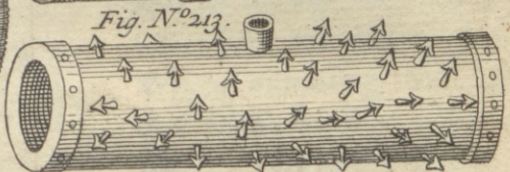
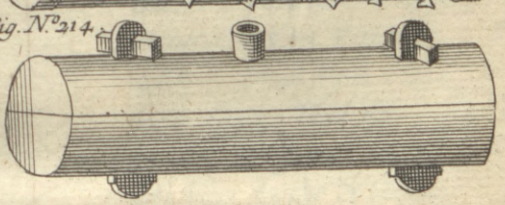


Fig. N.° 213.

Fig. N.° 214.



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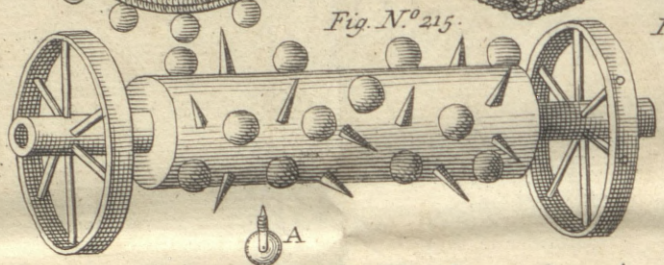

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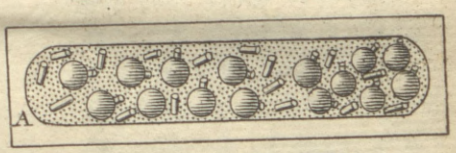

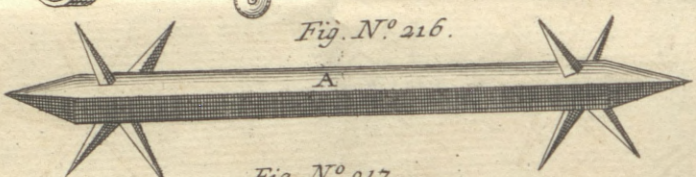

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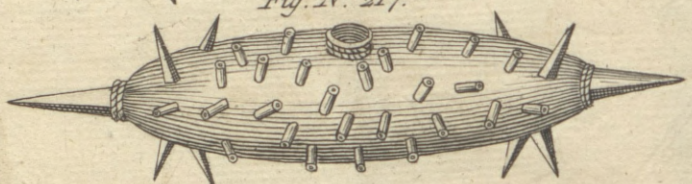


Fig. N.° 218.

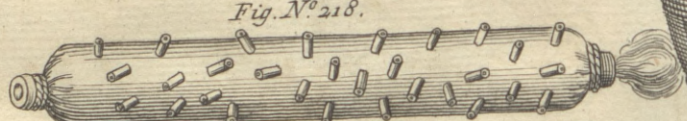


Fig. N.° 219.

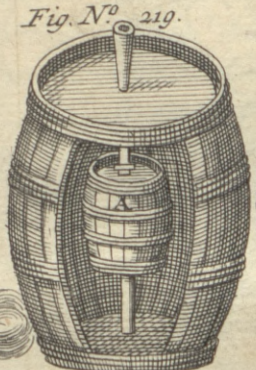
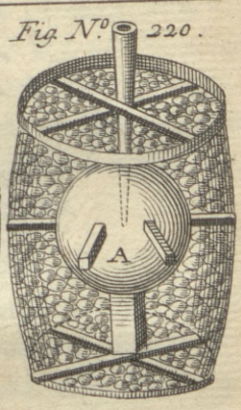


Fig. N.° 220.



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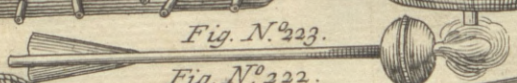
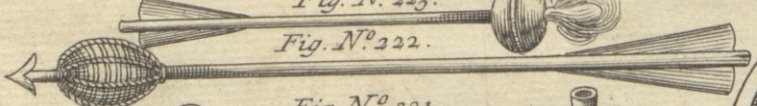


Fig. N.° 222.



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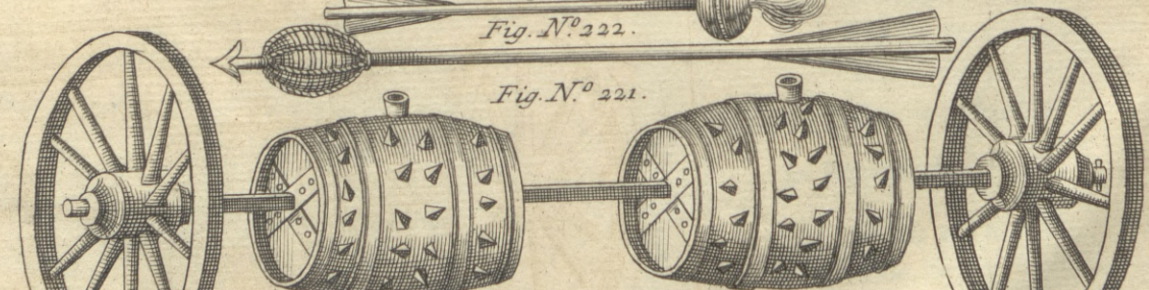

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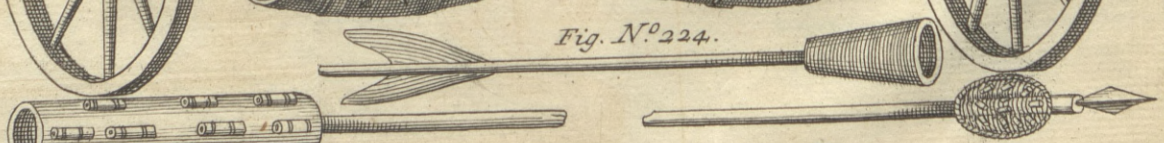

Fig. N.° 226.

Fig. N.° 229.

X

P.F. Sculp.

Compoſition, or into the Vents of the two others; the Uſe, and Neceſſity of which will come to you by Experience.

CHAP. IX.

Of FIRE-LANCES *or* PIKES.

OUR *Fire-Lances* are not unlike a Sort of long Javelins, which were anciently called *Phalaricæ*, and were uſually ſhot at the Enemy by *Engines*, or thrown by Hand. Hear what *Vegetius* ſays, concerning the firſt Way of projecting them: *That if the Inhabitants dared not ſtir out, they the more outrageouſly defended themſelves with* Malleoli *and* Phalaricæ, *which they ſhot flaming from the* Baliſta. We ſhall ſpeak of the ſecond Way of diſmiſſing them a little lower. Let us firſt ſee what we can gather from Authors concerning the Form, Preparation and Effects of them. The above-quoted Author, after having deſcribed the *Malleolus*, writes to this Purpoſe. † *The* Phalarica *is a kind of Spear, armed with a great Iron Head, between which and the Staff it is wrapp'd round with Roſin, Bitumen, and Tow ſteeped in Oil which is called* Fiery; *and being ſhot from the* Baliſta, *ſticks in any Wooden Works, and frequently ſets Fire to the* Machina Turrita. *Titus Livy* tells us, that the *Phalarica* was properly a *Saguntine* Weapon. ‡ *The* Saguntine Phalarica *was a Projectile Javelin with a long Staff, being armed with Fire (Tow and Pitch) and an Iron Head of three Foot in Length; that it might penetrate through any Armour, and pierce the Body, and that if it only ſtuck in the Shield, and did not hurt the Body at all, it might create Fear. Lipſius* adds to this Paſſage in *Livy*: *This is a terrible Weapon, both in the Blow it gives, and to look at; however, what was it but the* Lightning *that preceded our Modern* Thunder? *Silius* alſo mentions the *Saguntine Phalarica* from *Livy*.

Armavit clauſos, & portis arcuit hoſtem,
Librari multa conſueta Phalarica *dextra,*
Horrendum viſu robur, celſiſque nivoſæ
Pyrenes trabs lecta jugis cui plurima Cuſpis,
Vix muris toleranda lues, ſed cætera pingui,
Uncta pice, atque atro circumlita ſulphure fumat.
Fulminis hac ritu ſummis è mœnibus arcis
Incita ſulcatum tremula ſecat aera flamma.

In *Engliſh* thus:

With a *Phalarica*, whirl'd by many Hands,
The brave Beſieg'd repell'd the hoſtile Bands,

---

† Veget. Lib. IV. Cap. XVIII. ‡ Decad. II. Lib. I.

Back from their Gates. It was a mighty Oak,
Strange to behold; which for Defence they took
From th' *Pyrenæan* Hills. This arm'd around,
With bearded Spikes of Steel, would ſcarce have found
Obſtruction from firm Walls. The reſt beſmear'd
With Sulphur, and with unctuous Pitch, appear'd
Like a dire Thunder-bolt, and from the Walls
Of their ſtrong Ramparts down it ſwiftly falls,
Cutting with Quivering Flames the yielding Air. *Roſs.*

Lucan alſo in his *Pharſalia*, *Lib.* VI. verſ. 196, mentions the *Phalarica* after a very Poetical Manner.

The Majeſtic *Virgil* ſings as follows of this frightful Weapon, in *Book* IX. of his *Æneid.*

Non jaculo neque enim jaculo vitam ille dediſſet,
Sed magnum ſtridens contorta Phalarica *venit,*
Fulminis acta modo, quam nec duo taurea terga,
Nec duplici ſquamma lorica fidelis & auro,
Suſtinuit; collapſa ruunt immania membra:
Dat tellus gemitum, & clypeum ſuperintonat ingens.

In *Engliſh* thus:

Not by the feeble Dart he fell oppreſs'd,
A Dart were loſt within that roomy Breaſt.
But by a *Phalaric*', large, heavy, ſtrong;
Which roar'd like Thunder as it whirl'd along.
Not two Bull-hides th' impetuous Force withhold;
Nor Coat of double Male with Scales of Gold.
Down ſunk the Monſter-Bulk and preſs'd the Ground,
His Arms, and clatt'ring Shield on the vaſt Body ſound. *Dryden.*

Servius commenting upon this Paſſage in *Virgil*, gives us a particular Account of the Conſtruction and Form of this Weapon. *It is a large Arrow turned in a Leath, with an Iron Head of a* Cubit *long, at the End of which is a kind of Ball laden with Lead: It is ſaid to have* Fire *added to it by means of Tow ſteeped in Pitch; and being inflamed, deſtroys the Enemy by the Wound it gives, or the Fire it carries along with it. This* Spear *was thrown from Towers which were called* Phalæ, *from whence it was termed a* Phalarican Arrow *or* Javelin, *to diſtinguiſh it from the* Mural Arrows *which were ſhot from Walls.*

Tacitus in many Places calls them *Haſtæ Ardentes*, or *Fire-Lances* or *Pikes*; which Appellation of them we retain, by the common Conſent of all *Pyrotechnicians* and *Pyroboliſts:* For the *Italians* call them *Dardi de Fuoco*; the French, *des Lances & Piques a Feu*; the Germans, *Fewer Picken*; the Flemings, *Vyer-Spiſſen*; and in ſhort, we (the *Poles*) call them *Ogniſtæ Wlocznie* or *Kopüe.*

If you would ſee the Faſhion of our *Fire-Lances*, pleaſe to caſt your Eye upon *Fig.* 229. As for the Conſtruction of them, it is the ſame I directed for the *Fire-Arrows* and *Darts* of the firſt Kind: There is only this Difference between them, (*viz.*) That theſe are armed with a good Number of *Iron Crackers* prepared after the common Method; in which Reſpect they far exceed the *Phalaricæ* of the *Ancients*: Or on the contrary it is in Reſpect of this, that the *Phalaricæ* exceeded our *Lances*; for we ſhould find it a moſt difficult Matter to ſhoot them when prepared after our Way from our *Artillery*; as the *Ancients* were uſed to do from their *Baliſtæ* and *Catapultæ*, as appears by the Teſtimony of the Authors above-quoted. Fig. 229.

But on the other hand we have *Fires* that are more Artificial than the *Phalaricæ*, and which we can project from our *Cannon*, *Mortars*, &c. With theſe *Lances* we commonly arm our Men in Attacks and Storms, and in boarding of Ships: And indeed it is a terrible Weapon, if we rightly conſider the horrid Execution it does; for only imagine that a Soldier who carries one of them is armed with as many *Piſtols* as his *Lance* has *Iron Crackers* in it; and conſequently when he is thus armed, he muſt do as much Miſchief as ſeveral Muſqueteers. Farthermore, it muſt be conſidered that theſe *Lances* may not only annoy and gall the Enemy with *Powder* and *Ball*, but alſo knock them down, and gore them with the Staff and Head: Add to all which, that if the Effort be made, or the Attack carried on in the Night, they will ſerve to give a Light, by which may be diſcovered any lurking Ambuſcades of the Adverſe Party.

CHAP. X.

Of MILITARY FIRE-CASES.

I Here give you only one Sort of the *Military Fire-Caſe*, which you have in *Fig.* 226; and which in point of Form is exactly like the *Recreative Caſe* in *Fig.* 195. And for my part, I cannot ſee why we ſhould not apply our *Recreative Caſes* to Military Uſes; by ſtripping them of their innocent and diverting Nature, and in the Stead of that, ſubſtituting ſomething of deſtructive Effect, (*viz.*) *Hand-Grenado's*, *Crackers*, &c. as you may obſerve in the *Figure* itſelf, where inſtead of *Paper Crackers*, I have firmly fix'd others of Iron. Theſe differ from the *Recreative Sort* in another Reſpect, (*viz.*) That they are portable, as well as the *Fire-Lances* above-deſcribed. Upon the whole, I ſhall only remind you, that all theſe *Crackers* are to be fix'd ſo as to diſcharge themſelves directly upon the Enemy. Fig. 226.

CONCLUSION *and* APOLOGY.

Here (Candid Reader) you have the firſt *Eſſay* of my *Artillery* compleated; which I have performed with all the Care and Accuracy the Weak-

Weakneſs of our Nature would permit. If you and other worthy Perſons can collect any thing uſeful from it; I ſhall never repent me of the Trouble and Expence I have been at, nor of the great Portion of my moſt valuable Time which has been taken up in the Proſecution of this *Work:* But very far to the contrary; if I could know, that my Labour meets with a kind Acceptance from you, your Approbation would excite me to attempt ſomething of a more exalted Nature, and more worthy of you: All this is but the Prelude to what I meditate, if it be the Will of Heaven to ſecond my Deſign. I indeed muſt own, that I have omitted a great many Things in this little Work, as well in the *Recreative* as *Serious Part* of it; but it was through a Contempt of them, and not ignorantly that I paſſed them over; or ſome of them I thought fit to lay aſide for another Opportunity, and for other Reaſons; to which I might add the Importunity of the Printer, who would never let me reſt. In ſum, if I have any where fallen into Error, or if I have not given all the requiſite Graces and Embelliſhments to ſome particular Subjects (in which I know myſelf to have been often wanting) I ask your Pardon for it. I am neither afraid nor aſhamed of Reprehenſion, if it be given in a Friendly Manner: But as for rancorous *Critiques* (the Spawn of Envy and Ill-Nature) I laugh at them, inſtead of railing. But whither am I running to? Would it not have been more prudent in me to have reſtrained my Pen, and by my Silence to have preſerved the good Opinion my Friends had conceived of me; than to give into ſuch Flights, with Relation to an Affair in which many *Arts* and *Sciences* are concerned; amidſt the Multiplicity of which, it is not impoſſible but I may have been bewildered, and at a Loſs; and conſequently have laid myſelf too open to the ungenerous Attacks of the *Malevolent?* Yet all this gives me no Trouble; for I hope, my real Friends will have it in their Power to ſuppreſs the Calumny, and repel the unmanly Efforts of the *Ignorant* and *Envious*; with whom it were to no Purpoſe to contend, except I put myſelf upon a Level with them. In a Word, no overweening Fondneſs of my own Productions can ever blind me ſo effectually as to prevent me from being convinced of their Imperfections: I know and confeſs that I am but a Man, and conſequently ſubject to err; and to ſay the Truth, all Human Performances are very copiouſly interſperſed with Folly, Raſhneſs, Superſtition, *&c.* and amongſt them I am very well contented that mine ſhould be ranked: To ſpeak and conclude with *Scaliger*;

To the Beginning without Beginning; to the End without End; to the Day without Night; to the Workman without Hire; to the Creator without Expence; to Knowledge without Diſcipline; to the Triumpher without War; to Perpetuity without Moments; be aſcribed all Praiſe, Might, Majeſty, and Dominion, both now and for evermore.

FINIS.

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