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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M DCC XXIX.
The TRANSLATOR's

P R E F A C E.

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 hav-
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Having long been 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 cloistered 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 misled 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 Unreasonable 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
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 Pyroblest 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 Saltpeter, He suspects that the Confidence of those who hold them to be different Salts, proceeds chiefly from their being unacquainted with the Phenomena or Appearances of Saltpeter in the Making and Refining of it: And also to their comparing Double Refined Saltpeter (of which Gun-powder is made) with that Description 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 Egyptian Nitre was brown, and gritty or sandy; adding afterwards that there were Nitraria from whence the Nitre came out of a yellow Colour. This, Mr. Henshaw says, is sufficient to have hinted to any one but moderately versed in the Modern Way of ordering Saltpeter, that the Ancients were not at all skilled in Refining their Nitre from the Earth and common Salt,"
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"that is usually mingled with it; nor from that foul yellow 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 Nitraria, 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 yellow 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 Salispretræ Terris; or in Saltpetrous Earths; whereas Casimir has it Salispetrae Cirris, or in the Shrivers of Saltpeter; but it is likely that they may both be in the right. He then says, "That if a Salpetrous Lixivium be boiled up to a Consistence without filtering it thro' Ashes, or giving the Salt leave to Chrystallize, 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 afferts; by telling him, that near Sophia and Santa-Cruz, and in several other Places in Barbary, he saw Salpeter shoot out of the Surface of the Ground, as thick and white as Hoar-Frost, on many barren and desart Lands;"
"Lands; but that this does not happen till the beginning of the Rains in August or September, and that it is the falling of the Rains which causes the Saltpeter to shoot out in little Chrystals; and that the People of the Country take it up as clean as they can, and fell 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 fell 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 Chalaftriculum, 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 before. If during those Days that the Nitre is generated there happen to fall any Showers of Rain, they cause the Nitre to be saltier 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 Manner as common Salt; with only this Difference, that into Salt-Pits they pour Sea-Water, and into Nitriæ, Water of the River Nile.

Upon this, Mr. Henshaw says, "It will be no difficulty 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 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 Deserts of Africa under the Torrid Zone; where, by the Relation of Travelers, 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 Stiria 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 Stiria and in Stria. However this be, I shall not waste your Time with laying 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 everywhere 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 Fertility of the Earth; and he thinks they return not without 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 extracted from Dew, it is accompanied with a greasy purple Oil in great abundance; and adds, that upon Tryal he
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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 abound 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 necessarily have great Quantities generated in or infused into it, yet that in the 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 Dearts 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 Ingres the Air has the better, 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-uds 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 Auslitzer, or Berthold
Schwertz,
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"Schwertz, a Monk of Friburgh; which in all Probability was not long discovered when the Inventor (as Polydore Virgil tells us) taught the Use of Guns to the Venetians at the Battle of Poffa Claudia, when they obtained 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. Hensbaw 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 Fortis, 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 Gunpowder."

Thus far Mr. Hensbaw concerning the History of Saltpeter; 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 amis 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 Subiect.

As for Mr. Hensbaw'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
The Translator's Preface.

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.

Page 10 Line 37, for which will cut read which must cut. p. 12 l. 22, for least read left. p. 16 l. 30, for Fig. 8, read Fig. 6. p. 17 l. 24, for Cube 31 read Cube of 31. p. 23, 4 lines from the Bottom, for Vent read Windage. p. 24 l. 1, read the same. p. 38 l. 8, for Quality read Equality. p. 40 l. 28, for Rhomboides read Rhombus. p. 52 l. 8, for 52 Pounds read 72 Pounds, Ibid. l. 29, for MODUS read MODIUS. p. 61 l. 24, for 1 read 2. p. 65 l. 10, for Corphinus read Cophinus. p. 74 l. 24, for Cochlaeus read Cochlearia. p. 81 l. 7 from the Bottom, date that is, a Day's Journey and Form of a Field. p. 84 l. 8 from the Bottom, for Hetrurian Field read Tuscany. p. 90 l. 24, for lay read lye. p. 96 l. 7, for Staph read Spatula. p. 98 l. 6, for of common Salt of Verdigrisfere read of common Salt, 1 Pound of Verdigrisfere. p. 104 l. 9 from the Bottom, for I shall silently read I cannot silently. p. 121 l. 8, for White-Wine Vinegar read Spirit of White-Wine Vinegar. p. 126 l. 7, for burn them to that degree that they may read burnt to that degree that it may. p. 138 l. 20, for 1 read 2. p. 141 in the Margin, for 39 read 38. p. 160 l. ult. for Product read Sum. p. 190 l. 18, for read 4. p. 236 l. 13, for Poliocretum read Poliocretem. p. 262 l. 19, for to read by. p. 268 l. 35, for alternately read alternately. p. 292 l. 30, for Tin read Pewter. p. 297 l. 10, for rotten read rotten. p. 314 l. 39, for which were Games instituted by the Emperor Gallienus to be kept every ten Years, read which were celebrated by the Emperor Gallienus after a very extraordinary Manner. p. 368 l. 17, for his read this. p. 398 l. 23, for where read were.

OMISSIONS and MISTAKES in the PLATES.

In Plate D, Fig. 17, there is a W wanting at the Angle over-against the outward Entrance of the Ichnographic Figure. In Plate G, there is a P wanting over-against E in Fig. 48. In Plate H there are two 75, the lowermost of which should be 76.

DIRECTIONS to the BOOK-BINDER.

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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, Maßstab or Vier-Zaab; by the Flemings, Talßock; but much more properly by the Latins, Vigna, or rather Regula Sphærometrica; and which, in Derivation from them, we will call in English the Sphærometric 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,
Metal, from the Diameter of a Bullet of one Pound, or from that of a Lotb 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 laft 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 Unciae 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.

### C H A P. 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.
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:

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<tr>
<th>Roots</th>
<th>Cubes</th>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>8</td>
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<tr>
<td>3</td>
<td>27</td>
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<tr>
<td>4</td>
<td>64</td>
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<td>6</td>
<td>216</td>
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<td>7</td>
<td>343</td>
</tr>
<tr>
<td>8</td>
<td>512</td>
</tr>
<tr>
<td>9</td>
<td>729</td>
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</table>

2. In order to extract the Cube Root of any Number, as suppose 160103007; 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 subtract 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 subtracted from the above-said 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 subtracted 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 Subtrahend, 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 subtracted from the Resolvend, you will have no Remainder, as will appear by the Work itself; the whole Process of which is as follows;

\[
\begin{array}{c}
1601031007 (543 \text{ Root.}) \\
125 \\
75) 35103 \text{ Resolvend.} \\
\underline{32464 \text{ Subtrahend.}} \\
\hline
8748)2639007 \text{ Second Resolvend.} \\
\underline{2639007 \text{ Second Subtrahend.}} \\
\hline
0000000
\end{array}
\]

\[
\begin{array}{c}
5 \\
\underline{5} \\
\hline
25 \\
\underline{3} \\
\hline
75... \text{ Triple Squared} \\
\underline{60. \text{ Quotient.}} \\
16 \\
\hline
8116 \\
\underline{4} \\
\hline
32464 \text{ 54}
\end{array}
\]
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:

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,
6 Of the Great Art of Artillery.

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:

\[
\begin{array}{c}
3357 \\
3357 \\
23499 \\
16785 \\
10071 \\
10071 \\
\hline
11269449 \\
3357 \\
7886143 \\
56347245 \\
33908347 \\
33908347 \\
\hline
37831540293 \text{ Cube.} \\
32584707 \text{ Remainder.} \\
\hline
37864125000 \text{ Sum or Aggregate from which the Root was extracted.}
\end{array}
\]

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 the, 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 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, triple 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 you 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 Pounds, 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 calibrated 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.

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<th>Order of the Cubes</th>
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</table>
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 so 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 increase 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, Dioctepan by a Caffoidea or Hederacea, Menechmus by Conic Sections, and many others by the Parabola; but Eratothenes, Sporus, and Plato, have aimed at it by Right Lines and Curves; and even Pappus, Hero, Apollonius,
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Ionius, Pergaus, Philo Bifantius, 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 Battinus’s Treasury of Mathematical Philosophy, lately published at Bologna, where-in 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-
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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 among us; the two mean Proportionals found by Nicomedes by help of the Conchoid 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 Equidistant 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 increased in a certain Proportion, as well as the Things to be thrown, and this cannot be done without the Invention of a mean Proportional.

C H A P. 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 glo-
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rying in the Title of Fire Engineers in the Military Capacity, which the Flemings call Feld-Feuwerwercker, 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 confund & 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 Errors 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 faith, in an Arithmetical Problem, where he speaks to this Effect in his Latin Treatise. Let therefore our Mathematicians shou'd become 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 Lessons, looked upon the Mathematicks as a most powerful Queen with her numerous Husbands of Subjecks Sciences; whose Order, Subdivisions, Definitions, with their Differences and Distinctions, we have fully and clearly explained in our Lessons; 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 Virtue, 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 Errors, 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.
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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 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 Arithmetic 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 Falshits 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

E Practice
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 prick 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 between 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 ½ 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 ½ to the Diameter of a Bullet of 2 Pounds, and you will have the Diameter of a 3 Pounder.
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.

<table>
<thead>
<tr>
<th>Diameters of Bullets</th>
<th>Divided into Parts</th>
<th>Parts added to the Diameters</th>
<th>Make the Diameters of Bullets weighing lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>$\frac{1}{2}$</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>$\frac{3}{2}$</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>$\frac{5}{2}$</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>$\frac{7}{2}$</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>$\frac{9}{2}$</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>$\frac{11}{2}$</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>$\frac{13}{2}$</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>$\frac{15}{2}$</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>28</td>
<td>$\frac{17}{2}$</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>$\frac{19}{2}$</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>$\frac{21}{2}$</td>
<td>30</td>
</tr>
<tr>
<td>30</td>
<td>4</td>
<td>$\frac{23}{2}$</td>
<td>40</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>$\frac{25}{2}$</td>
<td>50</td>
</tr>
<tr>
<td>50</td>
<td>4</td>
<td>$\frac{27}{2}$</td>
<td>60</td>
</tr>
<tr>
<td>60</td>
<td>4</td>
<td>$\frac{29}{2}$</td>
<td>70</td>
</tr>
<tr>
<td>70</td>
<td>4</td>
<td>$\frac{31}{2}$</td>
<td>80</td>
</tr>
<tr>
<td>80</td>
<td>4</td>
<td>$\frac{33}{2}$</td>
<td>90</td>
</tr>
<tr>
<td>90</td>
<td>4</td>
<td>$\frac{35}{2}$</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
<td>$\frac{37}{2}$</td>
<td>200</td>
</tr>
</tbody>
</table>

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 performed with Instruments; but nevertheless, these are not purely Geometrical, though they may, in some sort, be called Mathematical; they may, at least, be ranked among those that are worked by Scale and Compasses 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 Compasses; but in the main they are merely Mechanical.
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 tranferally 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 Sектор: (See Fig. 8.) But if you have not the Convenience of a Sектор, 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. 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 observed 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.

<table>
<thead>
<tr>
<th>Order of the Roots</th>
<th>12</th>
<th>15</th>
<th>19</th>
<th>24</th>
<th>31</th>
<th>39</th>
<th>44</th>
<th>52</th>
<th>59</th>
<th>66</th>
<th>70</th>
<th>88</th>
<th>84</th>
<th>86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of the Cubes</td>
<td>$\frac{1}{2}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{8}$</td>
<td>$\frac{1}{16}$</td>
<td>$\frac{1}{32}$</td>
<td>$\frac{1}{64}$</td>
<td>$\frac{1}{128}$</td>
<td>$\frac{1}{256}$</td>
<td>$\frac{1}{512}$</td>
<td>$\frac{1}{1024}$</td>
<td>$\frac{1}{2048}$</td>
<td>$\frac{1}{4096}$</td>
<td>$\frac{1}{8192}$</td>
<td>$\frac{1}{16384}$</td>
</tr>
</tbody>
</table>

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
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again the Diameter of a Bullet of 4 Pound, and divide it into 4 Parts, and ¼ 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 ¼ 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 ¼ 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 Compasses of Proportion or Sector, transpose the Diameter of one Pound, taken with the common Compasses, transferely 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 transferal 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
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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:

<table>
<thead>
<tr>
<th>lb</th>
<th>Cube.</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>1,000,000</td>
</tr>
<tr>
<td>96</td>
<td>6,766</td>
</tr>
<tr>
<td>40</td>
<td>12304</td>
</tr>
<tr>
<td>36</td>
<td>2362 Remainder</td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>3076</td>
</tr>
<tr>
<td>144</td>
<td>12304</td>
</tr>
</tbody>
</table>
| 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 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 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 inferred 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, insomuch 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 answer 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 extremely 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.

---

**C H A P. 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 Christoper Clavius in *Lib. V. Folia* 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 Unciae 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.) 5½ 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 Unciae...
Of the Great Art of Artillery.

Uncia or Inches of the Rhynland Foot weighs 3 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 (vix,) as the Cube of the Diameter of 4 Uncia 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:

\[
\frac{64}{8} : \frac{8}{216} : : \frac{8}{64} = 8 \quad \text{(27 Pounds of Iron.)}
\]

\[
\begin{array}{c}
64) 1728 \\
\hline
128 \\
\hline
448 \\
\hline
448
\end{array}
\]

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 Uncia 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 Uncia 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 Uncia or Inches of the Rhynland Foot; which was required.
C H A P. 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 Bore 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, transferd 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.

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

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 Annotatons 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 nece-

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ry 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 Certain upon this Head, I shall subjoin what Mercurius (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 tie 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 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 Lathe; 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 Duport 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, be 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 ⅔ 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 Merfennus 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,

<table>
<thead>
<tr>
<th>Metal</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>100</td>
</tr>
<tr>
<td>Mercury</td>
<td>7 ¼</td>
</tr>
<tr>
<td>Lead</td>
<td>60 ¼</td>
</tr>
<tr>
<td>Silver</td>
<td>5 ¾</td>
</tr>
<tr>
<td>Copper</td>
<td>47 ¾</td>
</tr>
<tr>
<td>Brass mixed with Lapis Calaminaris</td>
<td>45</td>
</tr>
<tr>
<td>Iron</td>
<td>42</td>
</tr>
<tr>
<td>Common Tinn</td>
<td>39</td>
</tr>
<tr>
<td>Pure Tinn</td>
<td>38 ½</td>
</tr>
<tr>
<td>Leadstone</td>
<td>26</td>
</tr>
<tr>
<td>Marble</td>
<td>21</td>
</tr>
<tr>
<td>Stone</td>
<td>14</td>
</tr>
<tr>
<td>Chrysalid</td>
<td>12 ½</td>
</tr>
<tr>
<td>Sulphur</td>
<td>12</td>
</tr>
<tr>
<td>Water</td>
<td>5 ½</td>
</tr>
<tr>
<td>Wine</td>
<td>5 ½</td>
</tr>
<tr>
<td>Wax</td>
<td>5</td>
</tr>
<tr>
<td>Oil</td>
<td>4</td>
</tr>
<tr>
<td>Lime-Tree Wood</td>
<td>3</td>
</tr>
</tbody>
</table>

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 Ratios 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 ¼ is to 42.

This
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 Pounds; 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 Rations 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 Laths, or 13 ½ Ounces, or thereabouts.

By inverting the Order of these Rations, 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 Ration of their Specific Gravities in the above Table, for as 60 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 inferred 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 Rations 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 abovementioned, (viz.) 46400, by the 60 Cube Root, (as in our forementioned Table of Roots) which is about 393; now the Quotient 118, is the Diameter of a Bullet of Lead of equal Weights 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 one 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 man-
ner 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 compos'd, to the Parts of the Dia-
meter 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 \(\frac{2}{3}\) 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 Diam-
eters that are usually found upon the Calibre Scale. Moreover we may
not only have the Diameters of Globes or Bullets, but also all the Ho-
mologous Sides of any Bodies, as well regular as irregular (provided
they are made of such Materials as are to be found in our Table) toge-
ther 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 Num-
ber 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 \(\frac{4}{5}\), which
are the Number of Parts of the same Bigness, or Nature with those in-
to 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 re-
regular Body, may be done with respect to the Homologous Sides of an
irregular Body; and thus may you have the Magnitudes of equipo-
derant 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
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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 alloying, 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 Meffing, the Poles Mohads, and we Lattin) and 10 Pound of Tinn; (an Alloy 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 Aequiponderant Bullets, divided into equal Parts.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>100</td>
</tr>
<tr>
<td>Mercury</td>
<td>111</td>
</tr>
<tr>
<td>Lead</td>
<td>118</td>
</tr>
<tr>
<td>Silver</td>
<td>122</td>
</tr>
<tr>
<td>Brass or Copper</td>
<td>128</td>
</tr>
<tr>
<td>Brass with Lapis Calaminaris</td>
<td>130</td>
</tr>
<tr>
<td>Iron</td>
<td>133</td>
</tr>
<tr>
<td>Common Tinn</td>
<td>136</td>
</tr>
<tr>
<td>Pure Tinn</td>
<td>137</td>
</tr>
<tr>
<td>Loadstone</td>
<td>156</td>
</tr>
<tr>
<td>Marble</td>
<td>168</td>
</tr>
<tr>
<td>Stone</td>
<td>192</td>
</tr>
<tr>
<td>Chry halt</td>
<td>201</td>
</tr>
<tr>
<td>Sulphur</td>
<td>202</td>
</tr>
<tr>
<td>Water</td>
<td>266</td>
</tr>
<tr>
<td>Wine</td>
<td>267</td>
</tr>
<tr>
<td>Wax</td>
<td>271</td>
</tr>
<tr>
<td>Oil</td>
<td>276</td>
</tr>
<tr>
<td>Lime-Tree Wood</td>
<td>309</td>
</tr>
</tbody>
</table>
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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 $88 \frac{1}{2}$, 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, 50 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 $24 \frac{1}{2}$, 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 equiponderant Bodies, made of different Metals, such as Brafs, 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 I
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Moreover there are some weights that are used for weighing gold, pearl, coral, and other things of value only; and others for iron, copper, lead, tin, 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 xxviiiith 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 mina, and 120 of attica, or 1500 ounces, 1200 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. Merfennus, in his treatise of measures, weights and coins, affirms us, that 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 denars, or to 804,000 grains. From whence we see that the talent, as calculated by villalpandus, exceeds that of merfennus, by 6 pounds (of 16 ounces each) 8 ounces, 2 drams, and 2 denars. Some are of opinion, that the Hebrew had two sorts of the shekel, (viz.) the common one, or the prophane di-brachma, and the tetra-brachma, of the sanctuary, which was double the common one. But you may at your pleasure read villalpandus upon this head, where he disputes with great energy against Gregius, 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. ver. 8 was equal
equal to a Roman Denarius; of which in St. Matt. 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 Merianum 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 Leaf 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 Helipolis was 60 firmly walled with Flints, and 60 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 Hefychius, who both affirr 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 Feetus. According to Villainpandus it was equal to half of the Hebrew Talent; but according to Suidas and Hefychius, 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 Aristote 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 Egyptian, 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 (μια) was of two sorts (viz.) the Lesser of 75 Drams,
And the Greater (which was bigger than the new one of Salon) 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 1 Obolus; the Obolus into 2 Semi-oboli; the Semi-obolus into 3 1/2 Siliquae, 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 Avoirdupois Weight; or Avoirdupois. This was the Last 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 Trims 4 Ounces; the Quincunx 5 Ounces; the Semis 6 Ounces (which was also called half a Pound); the Septunx was 7 Ounces; the Baffis 8; the Diodrams 9; the Dextans 10; and the Decimus 11 Ounces. The Pound was again divided into other smaller Weights; as, 24 half Ounces; 36 Duelle; 48 Sicilia; 72 Sextula; 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 Unciae or Inches; this they called the Menstral or Measuring Pound, to distinguish it from the Ponderal or Weighing Pound. Now this Menstral Pound, (according to Galen in his 5th Book of the Composition of Medicaments) was a kind of Veal made of Horn, with which the Romans used to measure Oil; and was divided by certain Lines drawn either within or without into 12 Parts, which were called Unciae. Galen farther informs us in the 5th Book of the same Treatise, that the whole Menstral 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 answerable to a Tonn) is a Weight much used in Poland (where it is commonly called Barska) and is 50 Stones, or 1600 Pounds: I suppose them here to be Stones of Warlow, 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
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thus the whole Millier will weigh 1900 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 560 Pounds.

CARGO, or CARICO, Cargo, 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 Schiffpfund 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, 150, 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 Cheefe.

QUINTAL, QUINTALO and QUINTALIS; a Weight amongst the Spaniards and Portuguese. 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 Portuguese 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 $\frac{1}{4}$ of the Lesser Quintal, and is therefore 168 Pounds. In the Kingdom of Fex, 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 Nomius the Soldiers cried out: Quid fit? Balthas jaetas 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
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France (for Example) in the City of Paris, it is divided into 4 Quartrons, or Quarters, of 25 Pounds each. At Lions, Toulouse, 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 Zuris, or 5 Stanes, 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 Nuremberg and most of the chief Towns in Upper Germany it is 100 Pounds, 120 Pounds, and sometimes 132 Pounds. In Silesia and Prussia it weighs 5 Stones of 24 Pounds each, which is 120 Pounds; the same it weighs at Hamburg and Danzig. At Koningsberg it is 158 Pounds. At Lubeck and Stein 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, Flemings, Hollanders, and all the other Nations that inhabit the Borders of the German Ocean, and the Baltic Sea; as in Poland, Lithuania, &c. It is likewise used in Italy, (vizz.) at Rome, Florence, Bologna; as well as Hamburg, Lubeck, and Stein; in all which Places it weighs 10 Pounds: At all these Places they have likewise one of another fort, which is double of the first, and consequently weighs 20 Pounds. At Prussia 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 Danzig 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 Koningsberg it is also of two forts, the biggest weighing 40 Pounds, and the least 25 Pounds. At Elbing, Pillau 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 Wagels make a Sack, and 3 Sacks make a Seltier or Serpeltier. But in England the Nagel weighs 7 Pounds; 3 Hundreds and 4 make a Sack of Wool, which is 52 Nagels; the TOD is likewise an English Weight, and is 4 Nagels.
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 Sacebooks; into 24 Sexatios or Siclos; into 48 Denarii, 7 of which make an Ounce; into 96 Darquins, or Drums; into 288 Scruples; into 576 Orlofatts, or Oboli; into 864 Damigl; 1728 Kirats, or Carats, or Siliqua, and into 6912 Kestufs, which signify **Grains**. According to Nicholas Tartaglia, in his Twelfth Question, the Rotula or Rotula at Venice, weighs 2 Pounds, or 33 Ounces and ½, and 3 Rotules make 100 Ounces. In Sicily the Rotula 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 Drums) and one Rotula is 480 Metallicks, each of which weigh ½ Peño, and 10 Peño make an Onque, or Ongy; in fine, 50 Metallicks make a Turkish Mark; but 32 of them would constitute ours.

The **Mina**, **Maneeg**, 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 Pfund, in the Low-Countries, Pond, and by the Poles, Punt; 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 Merfennus, 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 1/10 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 1/100 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

L Grains.
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 (say 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 extreme 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 consequentially 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 88 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 5 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-
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By 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 Anglci, (which the Dutch call Engelfchen) 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 \( \frac{1}{4} \) 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 Lots or Half Ounces; each Lot weighing \( \frac{1}{4} \) Sicilica, which in the Language of the Country are called Slovic; therefore the whole Pound weighs 48 Sicilica. The Danzig Pound is in like manner divided into 32 Lots, and the Lot into 4 Quarters, which they also call Quintlere; the Quarter into 4 Segrers or Ponderal Nummules. Consequently the Danzig Pound is composed of 512 Nummules. Now since it happens that 32 of these Nummules make an Ounce of a Pound, it will necessarily follow, that 4 Nummules will make a Drachm, and thus a Nummule 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 Morfensis. Now in order to know what Proportion a Grain of the Danzig Pound, may bear to the Grain of a French Pound; please to take notice of what follows.

Peter Grugerus, one of the most famous Mathematicians in Danzig, assures us (in a little Treatise of Arithmetic which he wrote in Germany,) he had often experienced that the half Pound of Cracow (which he calls Gazyana, and the German March) weighed 16 Lots, and 12 Nummules of Danzig; that is, that the half Pound of Cracow is 12 Nummules heavier than the half Pound of Danzig of 16 Lots. From whence we may conclude, that the Danzig Pound is as that of Cracow, as 9216 is to 9648. But insomuch as it is the most current Opinion, amongst Goldsmiths, as well as the most received one amongst the generality of the Poles, that the Cracowian half Pound ought to weigh 7
Imperial Dollars, or Silver Crowns, and inasmuch as the aforementioned Peter Cugrus says he himself tried and found that 7 Dutch Dollars weighed 16 Lots, and 12 or 13 Dantzic Nommules, and that upon a second Tryal, he found that 7 new Saxon Dollars weighed 17 Lots 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 Cugrus, who having taken upon him to examine the Weight of the Cracovian and Dantzic half Pound, shall particularly flinch to what he says; that we may avoid the Confusion and Trouble, which a Diversity of Observations might introduce into our Discourse.

But since Mercurius in his Treatise of Measures, &c. makes the Imperial Dollar and that of Burgundy or Flanders (which the French call Pagens; 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 Warfowian Pound is an Ounce, lighter than the Dantzic Pound, as I myself have experimented, it weighing but 8640 Dantzic Grains; therefore the Warfowian 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 Drains, 2 Deniers, and 21 Grains. But it weighs 6610 2 French Grains. The Pound of Koningsberg bears such Proportion to that of Dantzic as 8121 4 does to 9216, as appears by Peter Cugrus, who found that 160 Pounds of Koningsberg, were equal to 14.1 Pounds of Dantzic. The Pound of Vilna is equal to 29 and 11 Lots of Dantzic, and weighs 8378 7/ of Dantzic Grains. The Pound of Norenberg is equal to 11511 Dantzic Grains; therefore it exceeds the Dantzic Pound by 2295 Dantzic Grains; which are equal to 7 Lots, 3 Drains, 2 Deniers and 5 Grains. That of Cologne weighs 39 Lots and 3 Nommules, or 11286 Dantzic Grains; therefore it exceeds the Dantzic Pound by 2070 Grains, or 7 Lots, 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 Cugrus 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 1 or 2 Ounces heavier than that of Cracow. Cugrus moreover observed that the Dutch half Pound (which is called Trojgewicht, and Trojbe Mark by the Germans) weighs 20 Lots 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 Lots and one Drum; whereas it exceeds the Cracovian but by 2232 Dantzic Grains, or 7 Lots, 2 Drains, and 3 Nommules. From whence we may conclude, that
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that the Ounce of this Dutch Troy Pound, as commonly divided into 20 Anglies, or into 640 Grains (which some mean by the Word Azen) contains 742 ½ of Danzic Grains; and consequently that the Danzic Grains are lighter than those of Holland. The same Dutch Ounce, (according to Willebrordus Snellius, in his Eratthosnititae Botanic. Lib. II. Cap. V.) weighs 9 Golden Rose-Crowns, commonly called Rofen-Nobel or Rose-Nobles, which Crugerus having tried, found that 4 of those Nobles or Crowns, weighed 2 Loths, 9 Nommules and ½ of Danzic, 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 Merfennus, concerning the Dutch or Batavian Pound, differ from this last; inasmuch as Merfennus 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 Danzic. 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 Silices, and 6912 Grains. At Vienna in Austria; the Pound is divided into 32 Loths, 128 Qyints, 512 Deniers, and 128,000 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 Silfains, the Silfain into 2 Drams or Qyints. In the Kingdom of Fex, 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 60 Drams, into 288 Scruples, into 576 Okals, into 1728 Silices, 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 3 ½ j, two Ounces 3 j, and so on till you come to half a Pound, which is thus expressed ibis; a Dram 3 j; two Drams 3 j; and so on to Eight. The Scruple thus ẓ; 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
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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 it self 2 Ounces. The Fourth with 8c. 2 Ounces, and by it self 1 Ounce. The Fifth 8c. 1 Ounce, and by it self 4 Drams. The Sixth 8c. 4 Drams, and by it self 2 Drams. The Seventh 8c. 2 Drams, and by it self 1 Dram. The Eighth 8c. 1 Dram, and by it self 1 1/4 Scruple. And the last 1 1/4 Scruple or 36 Grains.

Observe here that we have said, in the former Part of this Chapter, that the Hebrew Shekel, according to Merfennus, weighed 268 French Grains; but since Merfennus, in Lib. IX, of his Treatise of Measure, Weights and Coins, will absolutely have it, that the Imperial Dollar answers nearly to 2 Shekels, inasmuch as 2 Shkelis 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 Creootian Pound, it will infallibly be found to weigh 7504 French Grains. Again, the Low-Country Pound (whose Proportion to the Creootian 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 Merfennus, 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 Merfennus has assigned a Weight to the Imperial Dollar which would have agreed better with the Flemisb 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 M.A.R. of Money, which the Latins called Marcha and Libra Nummularia, or Nummarias, and which we shall call with them the Nummular Mark or Pound, is much used by Monnecyers, Goldsmithes, and all those who are concerned in the Manufacture of Gold and Silver. In Poland, that of Cracow is 8 Ounces, or 16 Lothi, which are equal to 17 Lothi, 7 Nommules, and 1 of Dantsic. That of Dantsic weighs also 16 Lothi, or 256 Nommules, or 1024 Quarters. The proportion of this to the above-mentioned half Pound of Dantsic 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 Dantsic Mark is particularly used in weighing Silver, and is divided into 24 Sicilies, 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 Dantsic. That of Antwerp weighs 8 Ounces, or 160 Anglies, or 5120 Grains; there likewise the Anglic is subdivided into 6 Carats; thus 960 Carats constitute a Mark of Antwerp; 200 of which Marks are Equiponderant with 105 common Pounds.
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Pounds of the same Place. The Dutch Mark is 8 Ounces, the Ounce 24 Noennules, and the Noennule 24 Grains. The Roman Mark is 8 Ounces, the Ounce 8 Drams, the Dram 3 Scruples, the Scruple 2 Oboli, the Obolus 3 Silices, and the Silic 4 Grains. The French Mark, according to Merjennier, 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 Silices, and into 4608 Grains. The Nummular or Money Pound of Florence is divided into 24 half Ounces, or Laths, into 288 Noennules, and into 6912 Grains. The Golden Mark of Genoa is 8 Ounces, or 192 Noennules, or 4608 Grains. At the same place the Silver Pound is divided into 12 Ounces, 288 Noennules, 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 Mijnia and Savoy it is 8 Ounces, or 193 Noennules, or 4608 Grains. And to conclude, that of Nuremberg is 16 Laths, or 64 Quarters, or 356 Primes or Noennules, or 1024 Sixteenths.

We have in fact 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 Equations and Ratios to one another. I would only observe to you, that if you are desirous of being further satisfied upon this Head, you may have recourse to a small Flemish Book, published by an Anonymous Author at Amsterdam, in the Year 1647, entitled Tyffer van de Gewichten, Mateen van Kor en Londen, &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 written 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 lb Roman; to know how many Pounds of Amsterdam it would weigh; you may proceed in the following manner. (viz.) as 100 lb Roman, are to 76 lb of Amsterdam, in the given Table, so is 60 lb 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 lb, 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 Merjennier's Book of Measures, &c. to prevent our being no more perplexed by the defects, and great and frequent Imperfection of Weights, than by the great Difference and Variety between them; but that we
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 Incredulity, 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 Equilibrium, 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; insomuch 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 several 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 Workmen 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 forever, may if their Confidence 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 endowed.

Let there be (for Example) two Braid 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 extreme 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, Semillartus, 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 leffened 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 leffened 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 are in vain perplex ourselves. Let us be well satisfied, if there should be a Grain or two of Difference between two

Weights;
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 Mechanics (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 Burton, in Guicciard, 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 Abridgment 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 Brachus or Beam of the Balance, and that $G$ is the Axis or Center. Now let us suppose that $A$ and $B$ are equidistant from $G$, and that the Weights suspended at those two Points will infallibly equiperate, if they are equal to one another; it being very evident from our general Postulate, that two Bodies of the same Weight, and at equal Distances from their common Center, are in Equilibrio, in the Point of their common Conjunction, and in the Termination of their equal Distances. Thus the

N Bodies
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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 equidistant from the Center, it will necessarily follow that the Point of Equilibrium 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 equiperponderate with F suspended at B; by which it must plainly appear, that for Bodies to be in Equilibrium, it is not only necessary that they be of equal Weight, but likewise that they be equidistant 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 equidistant 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 \( \frac{1}{4} \) of the Semi-diameter L, M,) then divide the Peri-
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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 Trumpet, 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 Constructions 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 Equilibrio, though at the same time they may be subject to Decretit. 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 Equilibrio. Let the shortest Brachium, for Example, be divided into 10 Parts, and the longest into 15; and let the Scale suspended by the Former weigh 10, and that suspended by the Latter weigh 15; and their Weights and Distances being by this Means in a reciprocal Proportion, they will be in Equilibrio; 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. &c, 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 Decretit 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 Equilibrio, 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 Equilibrium; 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 Equilibrium.

**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 Constructions 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 lb, and that suspended at G weighs but one lb, they will be in Equilibrium. For according to what was laid down in the last of the two Mechanical Annexes, (viz.) that unequal Weights will equaiponderate 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 equaiponderate. Some will have it that this Equilibrium 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 one Foot 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 laid 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 in 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
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Steel-yard raise the perpendicular B, D, upon the Right Line A, C; and upon the Line B, D, set off towards D, \(\frac{1}{6}\) of the Distance between A and B; let the Perpendicular B, D, be continued downwards as far as E, to the length of \(\frac{1}{6}\) 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, F; each of them equal to \(\frac{1}{6}\) 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 \(\frac{1}{6}\) of the Distance between A and B; let them be continued to L and K to the Length of \(\frac{1}{6}\) minus \(\frac{1}{6}\) of the aforesaid 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 \(\frac{1}{6}\) 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 \(\frac{1}{6}\) 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 \(\frac{1}{6}\) 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 Refemblance 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 Bracia and Axis of this Instrument, they must be referred to the Fancy or Difcretion of the Workman; but for such as are not Artits, 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 smalllest 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 lb, sometimes 10 lb and 100, or more or less according to the size of the Steel-yard, the use
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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.

O B S E R V A T I O N 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.

O B S E R V A T I O N I I.

Several Weights hanging at several Distances on the longest Bractium of the Steel-yard, may equiponderate 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.

O B S E R V A T I O N I I I.

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

O B S E R V A T I O N I V.

Of two Weights which seem to be, and are in reality in Equilibrio, the heaviest bears always such Proportion to the lightest, as the longest Bractium 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 equiponderate, or be in Equilibrio, 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 Equilibrio.

C H A P.
C H A P. XII.

The Ancient and Modern Liquid and Dry Measures care-
fully reduced 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 Pyrotechnian, or others who voluntarily apply themselves to the Study of the Mechanick: But here both Reason, and the order of Things, require us to affiliate 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, (cpxi.)

That both Liquid and Dry things vary infinitely with regard to Weight, which does not only arise from the Diversify of their Species, but we find it also in one and the same Species; 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 Rye, Rye heavier than Oats, Oats than Barley, and so on. Since then Things of one and the same Species 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 Ratio 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
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distance from it; and if you observe the Weight of Water before it is frozen, you will infallibly 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 distinctly 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 Perfons who drink of it. I shall likewise be silent with regard to several Oily Springs, one of which Phryn describes in his xxxi Book, Chap. ii, 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 Remark 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 Caffedorus says, Book iv, on the Variety, in the Letter sent by Theodoric first King of the Ostrogoths to the Earl Aprianus, (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 also 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 Arisotle; Seneca; Phryn; 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 shew 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 Falernum, Creta, 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.
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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 Specific 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 Alemicks, Still, 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 Specific 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 far 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, illis venient felicior usu:

Arboris etibus alibi, atque inujisca 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 assured by Merchants, who are the most experienced in this Branch
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Branch of Trade, that the Amsterdam Mсуд of Polisb Wheat, or of any of its circumadjacent Provinces, weighs 150 lb; that the fame Measure of French Wheat weighs 180 lb; of Sardian, 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 70 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 Consequences 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 endowed 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 when to sow when the Moon is in the Enerese; what in her Wane; what to sow when her Horns are sharp-pointed; and what, when the shines out with her full and borrowed Lustral. 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.

\[\text{Ante tibi Eoe Atlantides abcondantur,}
\text{Gnosique orientes decodat stella Corona;}
\text{Debita quam fulcis committas Semina, quamque}
\text{Invoce properis anni sperm credere terra.}
\text{Multi ante occasum Maiae capere: sed illos}
\text{Expellata segeti unam elisit arisbis.}
\]

In English thus,

But if your Care to Wheat alone extend,
Let Maias with her Sisters first descend,
And the bright Gnosian Diadem downward bend:
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Before you trust in Earth your future Hope;
Or else expect a little, lazy Crop.
Some Swains have frown 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 Specific 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 infer the Testimony of Merfennus, 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 afcer- "tain the Specific 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 Unciae 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 Unciae 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 rises 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; consequent- ly the Roman Ponderal Pound weighed 6432 of our Grains, which we have said from Merfennus 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 Bar- ley-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 Eu-
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rope that may be mentioned, those Pounds or Ounces may be easily reduced to what Weight 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 ¼ Culeus, that is, 2400 lb Menfural, and 2000 lb Ponderal of Rome; but of our Weight 1395 lb, 13 Oun. 2 Dr. and 2 Den.

CULEUS was a Leather Vessel, which held 20 Amphore of Liquids, which is 1600 lb Menfural, (witness Fannius and Columella,) and 1333 lb, 4 Oun. of Roman Weight; and of ours 930 lb, 1 Oun. 1 Dr. and 8 Gr.

MEDIMNUS was a Dry Measure, which held 6 Modii or 2 Amphore; that is, 160 lb Menfural, or 133 lb, and 4 Oun. Roman Weight, and 93 lb 7 Dr. and 6 Grains of our Weight. It held 144 lb 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 Medimnus, or 18 Modii, or 6 Amphore, or 480 lb Menfural, or 400 lb Ponderal of Rome, or 279 lb, 2 Oun. 5 Dr. and 1 Den. of our Weight.

HYDRIA was a great Pitcher to carry Water, and held 1 Amphore, according to Fellahians upon Genes; that is, 120 lb Menfural, or 100 lb Ponderal, or 99 lb, 12 Oun. 5 Dr. 1 Den. of our Weight.

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

AMPHORA, or QUADRANTAL, (witness Cato, Fannius, Columella, Valutius, Metanus, and several others) held a Urne, and weight'd, 80 lb Menfural, or 66 lb, 8 Oun. Ponderal; or 46 lb, 6 Oun. 3 Dr. 1 Den. and 16 Gr. of our Weight. This was a Dry Measure amongst the Romans, and held 72 lb of Wheat. Metanus, in his Reduction of this Measure to the Parisian Pound, says, that 72 lb Roman, are equal to 50 lb, 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 lb Roman were Ponderal; but as Authors conclude them to be Menfural, therefore as 72 lb Menfural are equal but to 60 lb Ponderal, it can be equal to but 41 lb, 14 Ounces of Paris; which
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we design to make use of in this Chapter, you must take particular Notice of it in the Seque 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 lb Menfural of Water, was equal to the Amphora. Diocles however will have it, that the Amphora held but 52 lb of Vinegar and 80 lb of Wine. Galen, on the contrary, says, that the Amphora held 72 lb of Oil, 80 lb of Wine, and 108 lb of Honey. Merifamus assures us, that he found (upon making the Experiment) that the Roman Cubic Foot, such as the Congiarius of Villalpandus, weighed 74 lb 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 Gessendus) that the Roman Amphora held 55 lb and 14 Oun. of Water of Parisian Weight; since the Congius, which is of the Amphora, holds (according to him) 7 lb minus $\frac{1}{2}$ of an Ounce of Water; from whence we may plainly discover that these 80 lb 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 Congius, or 40 lb Menfural, or 33 lb, 4 Oun. Ponderal, and of our Weight 23 lb, 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 $\frac{1}{4}$ of the Medimnum, and $\frac{1}{4}$ of the Amphora; this held exactly 24 lb 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 Menfural Pound; as a Liquid Measure, it held 26 lb, 8 Oun. Menfural, or 22 lb, 2 Oun. 5 Dr. 1 Den. and $\frac{1}{2}$ Gr. Ponderal, and of our Weight 15 lb, 7 Oun. 3 Dr. 2 Den. and 13 Gr.

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

The SEXTARIUS held 2 Hemina, or 1 lb Menfural, and a Bevis of 8 Ounces, which made 20 in all; or 1 lb, 4 Oun. 5 Dr. and 1 Den. Ponderal; and of our Weight 15 Oun. 3 Dr. 2 Den. and 5 Gr. The Romans had another Sextarius, which was called Sextarius Ruficatus, and was double of this.
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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 ¼ Gr.

The QUARTARIUS held 2 Acetabula, or 5 Oun. Mensural, or 4 Oun. 1 Dr. 1 Den. and ½ 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 ¼ Gr. Ponderal; and of our Weight 1 Oun. 7 Dr. 1 Den. and 9 ½ Gr.

CYATHUS was a small Measure in the form of the Acetabulum, and held 4 Cocalii 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 ½ Gr. of our Weight.

COCLEARIUM or SPOON was the ½ 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 ½ Gr. of our Weight.

Liquid and Dry Measures of the Ancient Grecians.

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

The ATRABA was 3 ½ Roman Medii, according to Cato and Columella.

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

The ATTICK AMPHORA was equal to the Metreta, according to Pausnius 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 ½ of the Cotyla, and the lesser but ½ of the same.

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

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

CHORUS, CHONER, or HOMER (as we have it in our English Translation) held 2 Lethec; it was equal to 1/3 of the Roman Culcus, or 14 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 1/3 of the Chorus, held 5 Baths or Ephi, which were equal to 15 Roman Urns, or 22 3/4 Modii.

The BATH or EPHA was 1/3 of the Lethec, and held 3 Seath, or 10 Omer; 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 SATOM, the 1/3 of the Epha or Bath, was two Hins; it was equal to 1 1/4 Modius, or 24 Sextarii of Roman Measure, according to Villalpandus. But Alexander will have it to have been equal to the Modius, by which he doubtless means the Attick Modius, that being 1/4 of the Roman. This Measure is mentioned in Genesis xvi. Ver. 8., and in St. Matthew v. Ver. 15.

HIN was the 1/3 of the Seath, and held 3 Cabs; it was equal to 12 Sextarii or a Congii of Rome; it is spoken of in Exodus xxix. Ver. 40., and in Ezekiel iv. Ver. 11.

OMER, 1/4 of the Epha, was equal to 7 1/4 Roman Sextarii; something is said of it in Exodus xvi. Ver. 37.

CAB, the 1/4 of the Hyn, 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, 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 Apophyma.

The EGG-SHELL, 1/4 of the Log, and 1/36 of the Epha, is thought to have held 2 Oen. 6 Dr. and 7 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
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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 lb, it answers to 160 Antwerp Stoops; but the Roba is only 5 Stoops. The Antwerp Stoop weighs 6 lb, and consequently the BUTT weighs 960 lb of Antwerp.

The PIPA or PIPE weighs 30 Robas of 28 lb each.

The ROBA is 8 Sommers.

The SOMMER is 4 Quartillas, each of which weighs ½ of the Antwerp Stoop, and consequently weighs 1 lb.

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 Henuegs or Annegras.

The HENNEGA is 12 Almudas.

The ALMUDA weighs 7 lb, 9 Ows, 14 Ang. and about 24 Gr. of Amsterdam Weights, and the Almuda is exactly ⅔ of the Amsterdam Alubo or Laß of Rye, that weighing, as we shall take Notice hereafter, 3200 lb.

CAVESCO is ¼ of the Amsterdam Laß, and consequently weighs 202½ lb 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 lb of Antwerp, consequently the whole Almuda weighs 48 lb of Antwerp.

The ALQUIER or CANTAR is ½ of the Almuda, and holds 6 Canadas, which are 4 Antwerp Stoops, or 24 lb ditto. With this they measure Oil of Olives.

The QUARTILLA is 13½ Canaças.

The STAR is a Liquid Measure used in Algarve, weighing 59 lb, 10 Ows, 15 Ang. and 26 Gr., or thereabouts.
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Dry Measure of the same Nation.

The MOI holds 15 Fangas.
The FANGA --- 4 Alquiers.
The ALQUIER --- 2 Mejus, 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 lb, 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 Seftieres.
The POT or QUART --- 2 Pintes.
The PINTE --- 2 Chopines or Hemines.
The CHOPINE --- 2 Demi-Seftiers.
The DEMI-SESTIER --- 2 Poffons.

From all this it follows, that the Muid of Paris contains 288 Pintes, and this it does, by an Order of Louis 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 Tonn of Wine. For, as by the Observations of Merfennus, it appears that the Pinte weighs 2 lb, it will follow that the Tonn or Muid, which contains 288 of those Pintes, will weigh 576 lb. But if we admit of the Lees, it will weigh 600 lb over and above the Weight of the Vessel itself, which is not to be reckoned. Merfennus 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 Bales, 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 ½ Feet, and towards “the Bottom or Bales 2 Feet only.

The Casque or Muid of Paris holds 78 Stopes of Antwerp, and sometimes 77, that is, 312 Pintes, or 308: It weighs 458 or 462 lb of Antwerp; since (as we have already said) the Stope weighs 6 lb, the Pint which is ½ of it ought to weigh 1 lb; 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 a Muid of Paris, and consequently weighs 1200 lb.
Dry Measure of the same Nation.

The MUID, or GREAT MUID holds 2 Tonneaux or Tuns, or 12 Seftiers.

The TONNEAU is ½ the Muid or 6 Seftiers.

The SESTIER is ½ of the Muid, and ½ 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 lb 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 lb; thus when the Boisseau is striked there will remain 12 ½ lb in it. Suppose now that the Muid contains 96 Boisseaux, we may naturally conclude that such a Muid full of Wheat would weigh 1536 lb.

The same Mersennus affirms 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, E. 1. Titre 10 ought to contain 18 lb, 6 Ounces, and 8 Scruples of Wheat; and in the same Place the great Muid is ordered to weigh 3648 lb.

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 lb 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 Boccale, and is divided into 13 ½ Robas or Stones each of which weigh 10 lb, but these Pounds are of 30 Ounces each. The Brenta is equal to 42 Stopes of Antwerp, by which means it must weigh 252 lb.

BOCCALE contains 2 Mezzoboccale.

BARILE, BARIL or CASK is a Tuscan Liquid Measure, which holds 20 Italian Bottles which they call Fiasco or Flask; 18 Stopes of Antwerp make a Baril which weighs 108 lb of Antwerp. As for the Fiasco
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Fiasco or Flask, it weighs 5 lb. 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 lb.

MOSTACHIO, or MOSTACIO is a Candian Measure, which holds 3 Stopes and 3 of Antwerp, and weighs 22 1/2 lb.

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

Botta is a Venetian Measure of 38 Mostachios, which they also call Zuchi, 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 lb, and is equal to the Roman Barile. The Bigoncio is equal to 72 Stopes of Antwerp, and weighs 432 lb.

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 Mostachios.

MIGLIARIO is a Measure much in Vogue throughout all Italy. At Venice it weighs 1210 lb. At Verona 1738 lb, and is equal to 8 Brentas, and 11 Baffes: As for the Brenta it is divided into 16 Baffes. At Pavia the Migliario weighs 1185 lb, which are equal to 83 1/4 lb of Antwerp. At Vincenza it is as at Venice. At Terzisa 1117 lb.

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 Terzisa.

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

Dry Measure of the same Nation.

QUADRANTAL is 3 Roman Modii, the Modius 8 Heminae, the Hemina 2 Sextarii. This Quadrantal weighs 52 lb, 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 1/2 lb and 1; 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 90 of Pavia; to 112 of Florence; to 102 of Vincenza; to 32 of Zara; to 48 of Ravenna; and to 29 of Terlou.

MOSA or MODIUS is a Venetian Measure, 7/8 of which are equal to an Amsterdam Last. In some other Places it is divided into 14 Pièces, each of which weighs 1 lb, each Pound containing 30 Ounces; in other Places it is divided into 4 Decalitres, or into 16 Se- stiers or Sextaries.

CORBA, among the Italians, is what the Latins formerly called Cordis or Corphius, and in English may be called a Basket. This is a Dry Measure. At Bologna it is equal to the Venetian Star, 3/2 of whose Corba being equal to a Last of Amsterdam.

MEDIMNUS, a Dry Measure in Sicily, contains 6 Modii, and each Modius 16 Sextiers or Sextaries. The Medimnus weighs 100 lb, 8 Ozen, and 3 Dr. or thereabouts of Amsterdam Weight; so that 38 Medimni are exactly an Amsterdam Last.

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

In the same Place they divide the Modius into 16 Gabenes, Sextiers or Sextaries; a Modius makes a Pontick in that Country.

MINA or MINALIT is a Dry Measure at Genoa and Verona; 23/8 of these Measure are equal to an Amsterdam Last at Genoa; but at Verona it will require 70.

BOMA or BOSULA is also a Dry Measure; 16 of these constitute a Last of Amsterdam.

SALEM, a Dry Measure in Sicily, holds 16 Tummena; it is sometimes of two forms, one of the smaller and lesser, 10 of the former and 8 of the latter constitute an Amsterdam Last.

The CA RAL in Bologna amounts exactly to the Venetian Star. This Measure is of two sorts, that with which they measure Rye, containing 36 Tummena, but of Barley it holds 48 of the same above mentioned. Thus the Care weighs 131/4 lb of Amsterdam. In short, 32 Cases of Rye and 26 of Barley constitute a Last of Amsterdam.

German, Liquid Measure,

RHUTHB holds 8 Fluid, 50; 5, 90; 4, 135; 3, 202; 2, 318; 1, 418; 1/2, 209; 1/4, 105; 1/8, 53; 1/16, 27.

FUDER, in Latin Vetus, is 6 Amphora, which are commonly called Acre, at all the following Places of Upper Germany, (viz.) Cologne, Wurz., Ulm, Braunschweig, upon the Main, Oppenheim, Wurtzburg, Mayence, and at Wurtemberg. But in other Places it holds 10 Acre; as at Heidelberg with Speyer; at Vienna, and all over Austria; 16 Acre or Amphora make a Culeus. Again, at Heilbronn, Durlach, and at Augsburg, 8 Ye or Acre make a Culeus.
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OHM or AME, which the Latins called Amphora, holds 20 Quarts, or 80 Measures, which, in the Language of the Country, are called Maffen; or 2 Urns, which they call Eimer. Those who have been at Cologne, Worms, Leipzig, Francfort upon the Main, Ulm, Oppenheim, Mayance, Nuremberg, Wirtzburgh, or Vienna in Austria, may know this. But at Heidelberg, and at Spire; 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 Augsburg 2 Modii or 12 Befontz 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 Nuremberg, Wirtzburgh, and generally throughout all Franconia, is divided into 64 Kans; at Vienna in Austria into 32 Öktaves, or 128 Seiltem; at Sabone and Brixem 144 Kans make an Urn or Eimer, and but 8 only constitute a Parcel.

The EIMER or URN in Misnia, and generally throughout all High Germany, weighs 36 lb; but at Leipzig it is 40 lb; and is divided into 3 Stubecken; and again into 4 Cantres or Kans, or (as they likewise have it) Maafs; and each of these Kans are 2 Noffels or Quarts. The Noffel is 2 Pints or Hemine, which they call Halb Karter, and the Halb Karter is 2 small Measures, which they call Maaslein.

MAAS or KAN, as it is called by the High and Low Dutch, and by the Latins Cantarus 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 Leipzig 23 Mensural Ounces make 26 1/2 Ponderal Ounces; but everywhere 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, Wirtzburgh, Mayance, Heidelberg, Spire, Strasburg, Falkenheim, and Durcheim, containing 80 Congii or Kans, will be equal to the Antwerpian Ame, of 50 Stopes, which (each Stope being 6 lb) weighs 300 lb, and consequently the German Pot or Kan must weigh 3 lb, 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, Rhust, and smaller Measures, &c.

Again; 128 Kans of Nuremberg, Wirtzburgh, Franconia, Vienna, and Augsburg, weigh 300 lb of Antwerp, and each of them apart weighs 2 lb, 5 Oun. and 3 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
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 Hamburg it is 3 Wispel, each of which contains 30 Modii, or Scheffel, as they call them: Now the Scheffel weighs 52 lb, 9 Ounces, 12 Ang. and 22 Gr. or thereabouts of Amsterdam; and therefore a Laß of 3 Wispel, or 90 Scheffel or Modii, will weigh 4734 lb, 3 Ounc. 1 Ang. and 28 Gr.

Observe here that this Wispel is equal to 6 Antwerpian Ams. Again, 83 Scheffel of Hamburg are equal to an Amsterdam Laß. At Rostock and Lubeck, 96 Scheffel make their own Laß; but 85 of them are equivalent to the Laß of Amsterdam. At Stettin in Pomerania 72 Modii or Scheffel constitute their own Laß, 4 of which is equal to that of Amsterdam.

SCHIEFFPFUNDT is a Sea Measure much used by those who border upon the German Ocean, and Baltic Sea. It is properly a certain part of the Laß, which comes near to the Medimum of the Romans, or to the great Modius, or rather to the Trimecimum which we have spoken of already. This is equal to the French Load, or the Spanish Cargio, or the Italian Carico or Carione. With this they not only measure all sorts of Grain, but also several other Species of Goods. At Hamburg it is divided into 20 Lippfundt, and weighs 300 lb. At Lubeck, Copenhagen, and Stockholm, 20 Lippfundt make a Schiefffundt, which weighs 320 lb. But I shall forbear speaking here of the Weight and Capacity of this Measure, (it being too explain'd hereafter) in a vast number of other Places where it is in use.

LISPFUNDT is an Aliquot Part of the Schiefffundt, as may be seen above, and may properly be called a Sea Measure. At Hamburg it weighs 15 lb; at Lubeck 16 Marks, and at Stralund 16 lb.

MALTER or MOLDER does not differ very much from the Schiefffundt in Weight and Capacity. It is a kind of Land Medimum, 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 lb; therefore the Malter weighs 320 lb in that Place. At Vienna and all over Austria it is composed of 32 Modii which they call Aisbel, or 64 Halb Aisbels or Spinten. Suppose now that this Modius weighs 21 lb and 14 Ounces of Amsterdam, the Malter will weigh 600 lb, and consequently 6 of them would be equal to a Laß of Amsterdam. At Cologne upon the Rhine 18 Medimi, or Malters, are equal to the same, supposing each of them to weigh 233 lb, 5 Ounc. 6 Ang. and 2½ Gr.
Liquid Measure of the Low Countries.

ROEDE is a Measure which answers to the half Culcus of the Romans. At Dort it is 10 Ames.
The AME is 10 Schrewes, and has some Affinity with the Roman Amphora.
The SCHREWEB 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 MENGEI, 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 Kann or Sextarius.

Then 10 Ames of Dort are 14 2 of those of Antwerp, of 50 Stopes; each Stope weighing 6 lb of Antwerp; and the Roede or Rod of Dort will weigh 4400 lb, and consequently the Am will weigh 440 lb; the Schrewes 44 lb; the Stope 4 lb, 6 Ounces; 8 Ang; the Kann 2 lb, 3 Ounces, 4 Ang. and in short the Pint must weigh 1 lb, and 12 Ang. of Antwerp.

This Roede is again divided into 2 Tuns, each of them containing 500 Stopes of Dort, or 2500 lb; to which if you add 50 lb for the Weight of the Tun itself, it will, when full of Wine, weigh 2250 lb, and consequently 2 Tuns will weigh 4500 lb. 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 Am is divided into 64 Stopes; therefore it weighs but 314 lb, 4 Ounces, 5 Ang. and 22 Gr. or thereabouts of Antwerp; each Stope weighing 4 lb, 14 Ounces, 2 Ang. and about 10 Gr. In Friesland, the Am 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 Friesland, and that what they call a Pint at Malines is a Mengel or Pot in Friesland; but as to the Am of Malines or Friesland, as well as of Louvain, Brussels, Bruges and Breda, they are equal in Weight and Capacity to the Am of Antwerp: But the Mengel of Louvain is equal to the Maas or Kan of the Germans. The Am at Brussels and Louvain is divided into 48 Stopes; at Bruges into 50; at Leyden, Delf, Treves, Flushing, Middleburgh in Zeeland, Ghent, Bruges in Flanders, and at Liège, it is divided into 60 Stopes. Again, 50 Stopes of Antwerp are equal to 54 of the Hague and Ruremond; to 72 of Ziricze, and to 26 of Newport and Ostend. I shall add to all this, that 14 2 Ames of Bruges, Middleburgh, Treves and Flushing are equal to 16 Ames of Dort.

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Besides this Roede which we have been speaking of, they have one of another fort at Bruges, which holds 2 Vessels or Tumns, each of 22 Sextario, or Seftos, each of which is 16 Stopes.

The TUNN of Beer throughout all Brabant, contains 54 Antwerp Stopes; but in Flanders 60, and sometimes 64 Flemish Stopes. As for the Dutch Tunn it is equal to that of Brabant, except that of Amsterdam, which requires 56 1/2 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 Stop.

Dry Measure of the same People.

The LAST or ACHANE, when it is used to measure Wheat, is composed of 16 Sea Medium, which the Dutch call Schippons, each of which weighs 300 lb; therefore the whole Last weighs 4800 lb; but when they measure Rye, 14 Schippons make a Last, each of which are equal to the former in Weight and in Capacity, consequently a Last of Rye will weigh 4200 lb 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 Bubels; therefore the Last is 108 Schepelen or Bubels. Again, they compute 29 Sacks in a Last, each Sack of 3 Okters, or Achtingen, as they have it. Moreover, 24 Salt Casks, or 21 1/4 of those narrow Vessels in which Flower is stowed, or 15 1/4 of the larger and broader of the same kind, constitute exactly a Last of Rye; again, 18 Tumns or Vessels of Beer; or as many Ame 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 lb or thereabouts; for suppose that the Quadrantals or Cask of Wine weighs 500 lb; 2 Tunns or 8 Quadrantals will consequently weigh 4000 lb; and 3 of the like Tunns, or 12 Quadrantals full of Rye, will weigh 4200 lb (without reckoning the Weight of the Vessels themselves) each of them containing about 360 lb 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 lb, and at other times but 4200 lb; and a Last of Rye weighs sometimes 4200 lb, and at other times but 4000 lb. Try a Last of barley, and you will find that it weighs but 3400 lb, 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 Mercennius the Parijhan Pound contains 13760 Grains of Wheat, which Pound is 16 Grains lighter than the Amsterdam Pound, this latter will contain 13776 lb, and the Last weighing 4800 lb, will certainly contain 66,134,860 of the same Grains. At Hemden 15 1/4 Tunns, or 4 Werfen or Bubels each, constitute a Last of their own; but 55 Werfen
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answer to a Laft of Amsterdam. At Antwerp the Laft is 32 Quarters, and the Quarter 4 Bushels, or Muckens, as they call them; thus 38 Quarters are equal to a Laft of Amsterdam. At Rotterdam 3 Oarves or Eightes make a Sack, and 38 Sacks make the Laft of that Place; but 87 Oarves are equivalent to an Amsterdam Laft.

The Mudder, or great MODIUS, is divided at Lewear into 8 smaller Measures, called Halfter; 13 of these are equal to a Laft of Amsterdam, as are also 10 ½ of Brussel, 7 of Magdebrich, and 12 ½ of Boifleduc. At Gant the Mudder 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 Mudders and 7 Halsters make 1 Laft 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 Laft of that Place, but the Amsterdam Laft requires 17 ½ of them. At Ypres 12 Razirees give a Mudder, each Raziere answers to 4 Tuns of that Place; and 25 Razirees make a Laft there: Again; 75 of these Razirees constitute a certain great Measure called Ikink, which is treble of the Laft. In short, they reckon 24 Razirees to an Amsterdam Laft. In several other Places of Lets note in Flanders the Raziere is divided into 4 Avois, the Avoi into 4 Pints, and the Pint into 8 lb. At Leuarden in Friesland the Mudder is 2 Lopen; 36 of these are an Amsterdam Laft. At Middleburgh in Zeeland the Mudder or great Modius, which they call Hoet, is composed of 16 Sacks; which may be properly called 8 Razirees, 41 ½ of which constitute a Laft of that Place, and 40 of them answer to that of Amsterdam. At Dort the Hoet is 8 Tuns, and 3 of these Hoet (which are a kind of Schiffpund) are exactly the Amsterdam Laft.

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 Congius, or Kamms, which the Poles call Garnieci. But by an Order issued out afterwards in the Year 1598, it is to contain but 62 Garnieci.

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 whence we conclude, that the Dantzick Tunn weighs 486 lb of Antwerp; and a Dantzick Stope weighs exactly 2 lb, 11 Oun. and 4 Ang. of Antwerp; and the half of it, which they call Halbe, weighs 1 lb, 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 Garnieci contains about 2 Dantzick Stopes of Liquor; therefore the Polish Tun of 63 Garnieci or Congius, is 56 Dantzick Stopes less than that of Dantzick; that is, that the Dantzick Tun contains more than that of Po-

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land by 28 of its own Garniee. Let us now conclude that the Polish Garniee, weighing 5 lb, 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 Garniee 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 Dimension, and suffered some small Diminution. To conclude; since the Polish Tunn of 62 Garniee weighs 334 lb, 12 Ounces, and 16 Ang. of Antwerp, it will be equal to ¼ of the Doliun, or to 7 Roman Amphora. As to the Weights of the half Garniee, which the Poles call Puligata, and the ¼ of that which is called Kwaarte-garcoune, it will be needless to enlarge upon them, after so much has been said.

The OHMA of Danzic holds 110 Danzic Stopes of Wine, or 20 Quarts, reckoning the Lees, but disallowing of them, it will be but 104 Stopes and ½ or 10 Quarts.

WHEAT is a Measure very well known in that Country, and contains 20 Garniee, Congus or Kashmir.

Dry Measure of the same Nation.

LASZT, or LASTE, is a Measure much in vogue in Poland, Livonia, Prussia, and Lithuania, and all the circumjacent 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 Last, a certain Quantity of any thing of a particular Weight; as for Example, the Last of Flax or Hemp at Danzic weighs 60 Stones, or 2040 lb of Danzic. Again, a Last of Hops is 12 Schiffsund of Six Medium, or 3890 lb of Danzic. A Last of Flower, Honey, Mead, Beer, Alkis, Tur, and Pitch is 22 Tuns; but 18 is a Last of Salt. As to Wheat and other Grains, the Last is almost throughout all Poland is divided into 60 Measures which they call Kores; but we meet with it of very various Capacity, and very different Weight. At Danzic the Last of Rye is 15 Schiffsund, each of which contains 4 Measures which we have elsewhere called Scheffel, each of which holds 10 smaller Measures called Matzen. In the same Place a Last of Wheat is 26 Schiffsund; 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 Danzic Last of Rye weighs 4245 lb of Amsterdam, though it weighs 500 lb of Danzic itself. For the Schiffsund weighs 340 lb of Danzic, containing 10 Stones of 34 lb each; but the other which is of a smaller Kind, and contains but 20 Liffund, weighing each 16 lb of Danzic, is used in weighing all other Commodities. Again; a Danzic
Of the Great Art of Artillery.


dic Læst of Wheat weighs 6440 lb, from whence we may gather the Weight of the Dantzic Scheffel or Modius; for it being 1⁄3 part of the Læst, it will weigh 85½ lb with regard to Rye, and with regard to Wheat it weighs 90 lb. 10 Ounces, 5 Quarts, and 1 Pond Nom. At Koningberg, and at Elbing the Læst weighs 6400 lb, and consists of 16 Schiffundts, each of which weighs 400 lb, or 20 Lipfundts; and 6 of these make 7 Læft of Amsterdam. At Riga, Revel, and Narva, 12 Schiffundts of 10 Stone, or 400 lb each, constitute a Læst weighing 4800 lb of those Places, and but only 4000 lb of Amsterdam.

KLODA, and MACKA is a kind of Dry Measure much used in the Lesser Poland, and Red Russia; that is, about Lemburg, Premilitz or Premislaw, and Yaroslav, extending towards the Carpathian or Krapakan Mountains, it contains 4 Modii or Quartis, or 8 half Modii commonly called Pulmirech, or into 16 Macka, or 32 Pulmarch; now at Lemburgh the Pulmarch is equal to 4 Polish Garnies or Congii, and the whole Macka to 128 of the same. From this it is evident, that 1⁄4 of this Measure is equal to the Old Roman Urna, and consequently that it answers in all to 32 Urns, or 1280 lb Roman. The Macka in Yaroslavo is 160 Congii or Garnies, (Kanu) but at Premilitz 130 only.

CWERTNIA is a Measure which may properly be called a Bime-dimus; for it holds two Medimmi or Korzez of Cracow. At Pólna it is 43 Congii or Garnies. At Kaliskie 26 Garnies, and the Wiertel Kaliski, is 14 Congii or Kanu.

KORZEC is exactly the Medimus of the Latini; that of Cracow is 16 Congii; by which means it happens to be equal to the Medimus or a Amphora, and answers to 160 lb Roman. In 1⁄4 part answers to the Old Roman Urn, or the Seab 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 Medimnus, moreover ¼ of this Measure comes nearly to the Grecian Amphora; and ¼ of it is not much less than the Latin Modius.

BECZKA or TUNN is the Dolium of the Latini: 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 profiled down; it weighs about 350 lb of our Punds: This is the Measure of Vines: That of Swedelie is 1 ¼ of this, and consequently weighs 315 lb. Besides the Measures I have already mentioned, there are several others in Poland, Lithuania, and Russia, of lesser Capacities; such as the Mirka, Storm, Qm arezka, &c. but these I shall pass over without further 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 Specific Gravity of Grain.
English Liquid Measure.

The Gallon contains 5 Pottles.
The Pottle ——— 2 Quarts.
The Quart ——— 2 Pints.

The Pint weighs one lb of Troy Weight of England, and consequently the Gallon will weigh 8 lb 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 Weight. Again, 2 Gallons make 1 Firkin, 64 lb.
16 Gallons ——— 1 Kilderkin, 128 lb.
79 Gallons ——— 1 Rainet, 148 lb.
94 Gallons ——— 1 Barrel, 256 lb.
128 Gallons ——— 1 Tierce, 336 lb.
192 Gallons ——— 1 Hogshead, 384 lb.
1,920 Gallons ——— 1 Keg, 1,008 lb.
1,536 Gallons ——— 1 Fess, 2,016 lb.

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

In Dry Measure of the same Nation:

A Peck holds 8 Quarts.
Quart ——— 8 Butts.
Buttel ——— 4 Pecks.
Peck ——— 2 Gallons.

The Gallon, as we have already said, weighs 8 lb; therefore the Weight of the Peck will be 32 lb.

They moreover reckon 4 Buttel in an Hafler, which is about a Sextarius, and 10 Hafler make a Last.

In Cornwall 20 Quarters make a Score.
In Ireland and Scotland the Buttel 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 Metalis of Tripoli, and every where else in Barbary, is 42 Rotules, and is equal to 7 1/2 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 1/2 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 Jobeins.

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

KIST or AASCAT into 2 Corbins or Hemia, as the Romans had it.

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

KELIATH into 2 Caffuk or Arsves, which equal the Roman Actabula.

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

CUATUM into 4 Salgerims, which are perfectly the Roman Coeblearii or Spoons.

Jobein amongst the Arabians is what the Congius was amongst the Romans, and what the Greeks called Hina; it is 1 1/2 Stope of Antwerp, and consequently the Dorach is 12 of the same Stopes.

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

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

SUBITHA is an Egyptian Measure, which is equal to 5 1/2 Stopes of the aforementioned Place.

DADIX is 4 Stopes of Antwerp.

COPHINUS is 3 of the same.

CHÆNIX of the Egyptians and the Antwerpian Stope are exactly the same.

The MARES and PONTEES are but 1/2 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 Caphile or Hemina, or (if you will) Hins : 45 or 50 of these Artaba make an Amsterdam Laste. The Egyptian Artaba is divided into 5 Aporrhimi or Aporrhime, or into 40 Chemices, or into 480 Insios or Inia, or (if you will) Sextaries: 45 Egyptian Artaba are equal to an Amsterdam Laste.

TOPIN or TOPIUM in the same Country contains 10 Chemices; as doe the Ephin 8 Sextaries or Inia.

CAPHICI is a Measure in Barbary which ought to contain 20 Guibès: 7 of these Caphibi 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 propos'd 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 Mechanics, to attain such a Knowledge in this Matter, as is not to be acquired but by long Study, and continual Practice.

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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 Geometers; and shall call them by the very Names they have given them. And first:

A FINGER, as it is called by the German, English, Dutch and Flemings; by the Polish, Poles; by the Latin, Digitus; and by the Hebrew, Ethab, 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 Merseinus 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 Scolependor 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 Scolependor is the least of all Seeds, since its Diameter is contained 2½ 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, Zoll and Daun, 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 Hands, 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, Lybas, by the Hebrews, Tophar, by the Germans, ein Spann, by the Poles, Piada, and by us a Span, in 3 small Palms, or 12 Digits, or 9 Unciae or Inches: This Measure (as Merseinus 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 Schuh, and by the Poles, Stopa, ought to be 4 Palms, or 16 Digits, or 12 Unciae 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, Iudorius, 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 this Division was somewhat perplexed and irregular, those who stuck to it, taking an Ancia for a Foot, divided it as well as every Integer (which they commonly called Ancia) into 12 equal Parts, one of which was called an Uncia; two of them a Sextans; three a Quadrans; four a Triens; five a Quincuncij; six a Semis, and so on to twelve, which constituted the Ancia or Foot. But our Geometricians having considered, that the Uncia 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
Of the Great Art of Artillery.

Frontinus's Book of Aqueducts, where he mentions two sorts of the Inch, namely, the Round Inch and Square one, and that the Round 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, Swenturus relates, that there are two sorts of it in the Town of Novemberg (namely) the Town or Civil Foot, which they call Stadt-Schuh, which contains 12 Uncia or Inches; and the Mechanick or Work Foot, which they call Werck-Schuh, which is but 11 of the same Inches, but this Foot they have divided into 12 equal Parts, which they call Uncia 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 Foot 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 Degen anticipated my Intention, by lately publishing a Treatise of Military Architecture; so that he has saved me of this Piece of Trouble, and got that Palm which I proposed to acquire at the Reward of such an Attempt; therefore finding that he has acquired himself very handsomely upon this Head, and that he has reduced all the Feet to that of Rhynland or Rhynland, I shall only transcribe them from him, for the use of the Pyrotechnic and others.

<table>
<thead>
<tr>
<th>Place</th>
<th>Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of Amsterdam</td>
<td>958</td>
</tr>
<tr>
<td>Of Antwerp</td>
<td>969</td>
</tr>
<tr>
<td>Of Athens</td>
<td>830</td>
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<tr>
<td>Of Aix la Chapelle</td>
<td>830</td>
</tr>
<tr>
<td>Of Antibes</td>
<td>830</td>
</tr>
<tr>
<td>Of Strasbourg</td>
<td>830</td>
</tr>
<tr>
<td>Of Babylon</td>
<td>830</td>
</tr>
<tr>
<td>Of Bonn</td>
<td>934</td>
</tr>
<tr>
<td>Of Bremen</td>
<td>934</td>
</tr>
<tr>
<td>Of the Brill</td>
<td>1070</td>
</tr>
<tr>
<td>Of Dart</td>
<td>1070</td>
</tr>
<tr>
<td>Of Geoffe</td>
<td>974</td>
</tr>
<tr>
<td>Of Augsburg</td>
<td>934</td>
</tr>
<tr>
<td>Of Augsburg</td>
<td>934</td>
</tr>
<tr>
<td>Of London</td>
<td>933</td>
</tr>
<tr>
<td>Of Marburg</td>
<td>900</td>
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<tr>
<td>Of Middelburg</td>
<td>900</td>
</tr>
<tr>
<td>Of Middelburg</td>
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<td>Of Middelburg</td>
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<tr>
<td>Of Middelburg</td>
<td>900</td>
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<td>X</td>
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</tbody>
</table>

"I shall"
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 whole Dimensions which 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 Cestius Statilius, which having been a little while ago discovered by James Melegbin (one of the best Architects belonging to the Pope) was through his Means removed to the Vatican Garden.

Moreover, Merfennus 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 \( \frac{1}{4} \), and is \( \frac{1}{8} \) or \( \frac{3}{8} \) 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 Merfennus, and which Vellipandus says he took from Cogius Farnesianus. The Measure of the Roman Foot which Philander has given us, exceeds the double of this last by \( \frac{1}{12} \), and its Proportion to the Rynland Foot is as 969 to 1000. Merfennus 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 \( \frac{1}{18} \); therefore according to my Observation the French Foot is to that of Rynland, as 1050 is to 1000. But we have paid 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 PICON 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 Digitis; 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 Fift.

The ELL, by the Hebrews, Ammach, by the Germans, ein Ellen, or Ellbogen, and by the Poets, Lokie, is 24 Fingers, or 6 Palms, or \( \frac{2}{3} \) Foot, or 18 Unciae. 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 Unciae 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 Degen.
<table>
<thead>
<tr>
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<th>Measurement</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Of Dantzick</td>
<td>1842</td>
</tr>
<tr>
<td>Of Hereford</td>
<td>1326</td>
</tr>
<tr>
<td>Of Florence</td>
<td>1846</td>
</tr>
<tr>
<td>Of Francfort upon Main</td>
<td>1760</td>
</tr>
<tr>
<td>Of Hamburg</td>
<td>1842</td>
</tr>
<tr>
<td>Of Leyden</td>
<td>2187</td>
</tr>
<tr>
<td>Of Lubeck</td>
<td>1842</td>
</tr>
<tr>
<td>Of London</td>
<td>2904</td>
</tr>
<tr>
<td>Of Middleburgh</td>
<td>2105</td>
</tr>
<tr>
<td>Of Noremberg</td>
<td>2105</td>
</tr>
<tr>
<td>Of Oudewater</td>
<td>2105</td>
</tr>
<tr>
<td>Of Revel</td>
<td>1768</td>
</tr>
<tr>
<td>Of Riga</td>
<td>1768</td>
</tr>
<tr>
<td>Of Toledo</td>
<td>2500</td>
</tr>
<tr>
<td>The Vara of Lisbon</td>
<td>2662</td>
</tr>
</tbody>
</table>

To this I shall subjoin, from Merfennus, that the Paris Ell contains 5 French Feet and 7 ¼ Inches; consequently it will bear such Proportion to the Rynland Foot (according to our Observations) as 3806 and ¾ 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, Merfennus affirms us, that the Brocchio or Brace of Florence (which is a kind of Ell) bears such Proportion to the French Foot as 45 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, Greffus, or Paffus Simplici, the Germans ein Einfacher Schritt, the Dutch een Step or Trede, and the Polek Kroek, ought to be 2 ½ Feet long.

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

The ORGYA or Fathom, which the Germans call ein Klaister, the People of the Low Countries een Vademe, and the Polek Zazen, ought to be 6 Feet long; Julian the Acolomite, an excellent Architect, would have this Measure called an Ell.

The CANNIA or REED, which the Hebrews called Kenrech, is 6 of the Hebrew Ells. Merfennus maintains that this Measure contains 8 Feet and 1 ¼ 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-rute, or Stange, by the Flemings een Roede, and by the Polek Prent, was formerly divided into 10 Feet by the Ancient
Of the Great Art of Artillery.

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 signifciant Terms upon all Occasions, called those Geometricians of his time that used this Measure Decempedatorum. Its Length is varied infinitely at present: As for Example; in the Low Countries the Rhylandic Parch is 12 Rhyland 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 is subdivided into 10 Unciae. In Poland and Prussia the Parch is 15 Feet, or 7 ½ of their Ells; this is what they call Gulmenic, but commonly Pret, or Miara Chelmenska. In the Territory of Nuremberg it is 16 Feet. In the Marquise of Brandenburg 12 Feet. In France (according to Merfennus) 22 Feet make a Parch. In the Territory of Ghent 14 Feet, but everywhere 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 Unciae. In England the Parch is 16 ¾ 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 Schuh and Kette: This is what the Romans formerly meant by the Arripendium; the Poles call it Szmur and Weifysko, with whom it is 10 Perches: But its Length is not always the same amongst Surveyors.

The STADIUM or FURLONG, and the Aule, Rolfe-lauff of the Germans, and Stasia 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 Breasting.

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 Thouand, 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 another; and that you may see the different Measures with which Geographers determine the Distance of Places: These are reduced to the Rhyland Foot; (which we here own to be equal to the Roman) the whole according to the Calculation of Degen.
### Of the Great Art of Artillery

<table>
<thead>
<tr>
<th>Country</th>
<th>Miles</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>-25,000</td>
<td>Schanos</td>
</tr>
<tr>
<td>England</td>
<td>-5,454</td>
<td></td>
</tr>
<tr>
<td>Burgundy</td>
<td>-18,000</td>
<td></td>
</tr>
<tr>
<td>Flanders</td>
<td>-20,000</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>-15,750</td>
<td>Lieue or League</td>
</tr>
<tr>
<td>Germany</td>
<td>-22,500</td>
<td>Lesser</td>
</tr>
<tr>
<td></td>
<td>-25,000</td>
<td>Greater</td>
</tr>
<tr>
<td>Holland</td>
<td>-24,000</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>-26,666</td>
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</tr>
<tr>
<td>Spain</td>
<td>-21,270</td>
<td>Legua</td>
</tr>
<tr>
<td>Hircanian Way</td>
<td>15,000</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>-5,000</td>
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</tr>
<tr>
<td>Lithuania</td>
<td>-28,500</td>
<td>Mila</td>
</tr>
<tr>
<td>Moscow</td>
<td>-3,750</td>
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<td>Scotland</td>
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</tr>
<tr>
<td>Sweden</td>
<td>-30,000</td>
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</tr>
</tbody>
</table>

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, Morgenh und Fauchart, and the Flemings, 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 67,500 Square Feet. From whence it appears, that the Polish Acre is bigger than the Old Roman one, which they called a double Square or Abus, 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 shown.

Again; let us add that 30 Square Acres of Lithuania and Warsovia, constitute a certain Measure or Portion of Ground which the Latins called Mansta 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 Huje. 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 Warfovia they divide the Breadth of the Acre into 2 Zagom 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 Rhynland 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 let 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.

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. 13. And that the whole land thereof is Brimstone and Salt and Burning, and that it is not sown, nor heareth, nor any grass groweth therein, like the overthrow of Sodom and Gomorrab, Admah and Zeboim, which the Lord overthrew in his Anger and in his Wrath.
Of the Great Art of Artillery. Book II.

Lib. xxxi. Cap. vii. and x. as does likewise Vitruvius, Lib. vii. Cap. xi. Aristotles, 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 Afro-nitre 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 Constitution or Form of it was various; for some of it was porous and spongy; 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, Exeter in a Dispute with Cardan concerning Subtily, 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 Herterrian Field, called the Valley of Eefa, 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 Fine-
ness of its Parts which are very subtile and aerial. I shall here infer the
following Words from him, because they will not a little contribute to
the Proof of this Matter. For as some Salt is Poffil, some extracted from
Sea Water, some from Springs, and some from Ashes; or as Glass is pro-
duced 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
Poffil 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 en-
tirely absorbed by it. Wherefore the Poffil Salt is more terrefrious or ear-
thy 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 earthly than that, because it is less aerial?
And that more aerial than this, because it is more refined in the Nitraria
than in Caverns? The fince Particles of that which shoots out of the Sur-
face are exhaled by the Sun; but in Caverns it is quite otherwise. Muft
not therefore the Cavernous Salt be more crafts or grofs, because it is less re-
 fined? Muft as green Fruits are more crude, than those that are ripened,
and have imbibed the Sun-beams. The Poffil is more grofs than the Sea
Salt, as well on account of its Confection or Preparation, as of its Subjance.
This is too Aqueous, and that is too Terrefrious; and neither of them is sub-
tile as Saltpeter. There is a Moisture that is in some degree natural to Ni-
tre; 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 heft:
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 left pure. That which ad-
heres to Rocks where it is dried up, (from whence it is called Saltpeter,) bears a great Analogy and Likenesf in Nature to Nitre itself; but it is more
Aerial, and rather inclining to the old kind of Afronitre; for we have fre-
cently observed a kind of Lufire 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 per-
fet and an imperfect Mineral; between one that is pure and refined, and
one that is rude and grofs; between what is subtile and aerial, and what
is earthly and crafts; in short, as much as is between a Spirit and a Body.
We may then conclude that Saltpeter is the nobleft kind of Nitre. That
the fort in ufe 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 witnes, 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 Salt peter 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 near-
ly 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 some-
times 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 ex-
actly 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 Inheritan-
ces of Princes, and wafted 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 Defeat 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 Per-
fection, that it yields neither in Form nor Virtue to the Salt peter of Plin-
ny, 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 Salt peter, or Salt condenfed into a Stony Confitence, 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 Crevices of old Buildings, where it is condenfed, con-
creted, or petrified in little Furrows; for as Art is the very Ape of Na-
ture, 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 exhi-
bited by excellent Artists, after a long and assiduous Labour, which can-
not 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-
Book II. Of the Great Art of Artillery.

Salt peter 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; insomuch 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 Gunpowder was found out; but in process of time, and as our Days increase 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 Pagonatos Emperor of Greece, is not very repugnant to our Opinion: But there are those who assure us (though they are not much credited) that Marcus Graccbus 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 Semi-
maurus (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 surprising 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, Kohin, &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, puae non habemus inventa ab aevi iilo 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, Arabs 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
Defis & Ilirica quae venit Iris hument.

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

And again,

Thus ubi misceris radenti tubera Nitro;
Ponderibus jujis fac sic utrumque trabent.

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 seafoned 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 Calisfrine Nitre, which was found in great quantities in the Quarries of Clytes in Macedonia; which was excellent Seafoning, 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 benefacient Salpetra, &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 χαλκωτοπία and χαλκωματοπία; 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 Salt-
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 the

Thus 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 consequentially hear that Clamour which usually attends the burning of Saltpeter, and other Things wherein it is incorporated. Let not this appear strange; for Chestnuts, 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 Carcasses lay covered with Earth: Such Places as these have for many Years past been ravaged, where great Quantities of Salpetrous Matter have been found, particularly in Wallachia, and in the Desarts of Podolia, between the Boh and Borišhenes: 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 Coffacks, who have rebelled against them.

But, O God! be thou propitious to the Enterprizes of 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 avenging and victorious Arms justly chastise the Insolence, and mow down the Heads of those turbulent Spirits, who though always born to Servitude,
tude, yet like wild and reftif Afies, have always refifted againft the Spur, and formerly refufed a Submission to the mildefi Laws of their Sovereigns; and now not contented with a Prospect of Liberty (a Happi-ness too reftined 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 fhall 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 Car-kafs upon dead Carkahfs, and made difmal 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 thefe newly-deftroyed Carkahfs to the old ones, whose faithlefs Foot-steps they purfued. From thefe Monuments of Mortality and juft Vengeance will Posterity have ample and glorious Subjeft, whereon to yield immortal Thanks to the Heroic Virtues of fo powerful a King, when they fhall with Aftoniffment behold the Trophies of fo compleat a Victory, infinitely furpafting those fames Pyramids erected of old by the Vanity of Memphis, and which paffed for Wonders amongst the An-cients. From hence likewise, from the Putrefaction of thefe Rebels, may be extracted Saltpeter, wherewith to make thunder-imitating Gun-powder, the Stench of whose Smoke fhall have the fame Effect upon the Remains of that ungovernable Race, if ever they revive fuch fatal Commotions, as the offensive Effluvia of the burnt Body of one Bug have upon its Survivors, which, according to Naturalisjs, destroy or deprive them of their noxious Qualities; like thefe therefore fhall they all be destroyed, or being difarmed of their inverterate Untractable-ness, be obliged to live peaceably under the Yoke of the Prince, whom Heaven fhall fet over them; or elfe taking a distant Flight with fuch as are Enemies to their Country's Quiet, and dreading the Punishments they may juftly expect; lofe all Inclination, and never once entertain the leaft 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 Hofs will bring to pafs, if he fees it will contribute to the Glory of his Holy Name. But I forget how infenfibly I stray from my Subjeft; let us therefore refume it, and confider a little on the Methods of trying the Goodnefs 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 extrac Salt peter; and which are the moft practifed by Per-sons concerned in this fort of Work.

The First as follows: Take a little of the Earth, which you ima-gine to be productive of Salt peter, 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 ad-
vice 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 preferve
the Ashes. Then take two Parts of these Ashes, and three of Quick
Lime, and incorporate them well together, and let 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 strewn the Bot-
tom 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 up-
on a Layer of Earth, and a Layer of Earth upon a Layer of Compo-
sition, 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 Mafs
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 wafted; 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 cleaned 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 subsidge 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 crystralize.

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 Crystal, 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 ⅔ 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 spread 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 Ebulition, together with what Liquor re-
 mains, after you have extracted what Salt peter you can from it after re-
peated Boilings (separating from it the Terrestrial Matter and the com-
mon Salt, which subsides, 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 Salt peter as it was at first, if not more, and
which you may easily extract after the Method we have here given.

C H A P. III.

How to clarify or refine Salt peter.

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 itself; 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 oftener if need be, that you may have it
in the highest Degree of Perfection; and this you may do by two Me-
ths.

The First. Be there taken as much Salt peter 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 boil-
ed together till the Salt peter 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 anoth-
mer 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.
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leisure in some retired Place; and in two or three Days you will have your Saltpeter chrysalized 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 quickened 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 viscid Humour, together with all the droppy 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 Constitution of white Marble, or of pure and perfect Alabaster.

C H A P. 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 Constitution of a dense Liquid, keep incessantly stirring it as quick and as fast as you can, till all the Moisture is evaporated ad finitatem, and that it is all reduced to a very fine, white and dry Flower.

C H A P. 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,
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fays, he found to answer very well at Bruffels 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 Denfity, 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 Goddes Vesta, had put some threads 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; (fays 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 Subtilty, 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 3 1/3 ij, and of Camphire 3 1/3 fs, and mix them all well together in some Brafs 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 ap-
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 lb in 100 lb; 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 lb of its Weight, as before,
C H A P. 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 lb of Quick Lime, 2 lb of common Salt of Verdigrase, 1 lb of Roman Vitriol, 1 lb 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 Salpetrous Liquor cool, and go on with your Process, according to the Rules we have prescribed in the third Chapter of this Book.

C H A P. 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 Drofs that swins 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 some
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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 subtle. 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 Alum, 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 lie 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 Iceland 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 Heidelberg, (as Agricola writes, Lib. I. de Effl. Terr. Cap. xxii. from the Testimony of Job. 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 beautify 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.
CHAPTER 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 size 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 mattress (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 mattress; 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 lb., of lime 1 lb., of sal ammoniac ½ iij.

Besides this, the chemists 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 Tribonius 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.

CHAPTER
C H A P. 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 seared: 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.

C H A P. 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 happy 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, tie 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
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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, Piéts, 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-sieve, 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-
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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 imitate 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 drive out the Ball that it will all burn out at the Touch-hole. How it comes to pafs that Gun-powder, by being bruifed, and reduced to a soft Flower or Meal, lofses thus its Virtue and Activity; muft be owing to the Rays of Fire, which though it be the moft 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 feizes upon it. This Affertion needs no Proe£f to confirm it; for Experience fhews us, with regard to Metals, that the more folid and hard they are, the lefs easily are they acted upon by Fire; on the contrary, fuch as are more porous, and loofely compacted, are quickly heated; which is to be attributed to the Large-ness of their Pores, which readily admit the Fire. This may be applied to Gun-powder; for when it is rammed and compelled into a folid Body, the Fire not meeting with Interfices proper for its immediate Conveyance through the whole Mass, it is obliged to confume it by degrees, as long as any of it remains, except it be fuffocated. Something of this kind may be faid of Powder that is scattered about, and is not gathered together before it is fired; but nevertheless with this difference, That in this Cafe the efential Strength of the Gun-powder, or rather the Fire in it, is not any way diminished, but its Action is ineffectual because of the Diftance of its Parts; it acts in this Cafe by a Succeflion of Small Acts, which might have been confiderable if collected together into one Act. Thofe who are but little verfed in Pyrotechnics, may have experienced the Truth of what I have here faid. The Reafon I have given why Powder when it is corned is more active and powerful than when pulverized, may serve in fame meafure to clear up that Difficulty; and to which, the Virtue of the Saltpeter seems to be much more united with the Sulphur and the Charcoal when in a clofe 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 let fire to it at the Muzzle, and not at the Touch-hole as ufual; neither the Fire nor the Powder in this Cafe will do the leeft Damage to the Piece, inasmuch as the Fire acts upon the Powder by Progreffion and not Inf tantaneously; besides the Fire will move downwards, which is the reverse of its natural Property of acting upwards; or to fpeak more properly, it not being clofely confined, and meeting with nothing to obft rubbed its perfect Liberty, it burns out at the Muzzle of the Piece. I fhall silently pafs over the Opinion of fome 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 unlikey, and seems to agree with what I have been faying above: But on the other fide, the Confequence of it is wrong; because large Grains are not fo readily acceeded, or inflamed, as small ones; and Experience in Fireworks teaches us, That that Powder which is in the leeft Corns, is more vigorous than that whose Grains are the largest; and the Reafon is, because the small ones conceive the Fire more readily: Add to this
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this, that they are more impregnated with Salt-peter (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 Ordnance 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 ascending 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.

E e

Chap.
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 lb, of Sulphur 1 lb, of the Pith of Elder well dried one lb.

2.
Take of Saltpeter 10 lb, of Sulphur one lb, of the Rind or Bark of Hemp, after the Hemp is taken out, one lb.

3.
Take of Saltpeter 6 lb, of Sulphur one lb, 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, 3 j.

Red Powder.

1.
Take of Saltpeter 6 lb, of Sulphur one lb, of Amber 1 lb 6 s, and of red Sanders one lb.

2.
Take of Saltpeter 8 lb, of Sulphur one lb, of Paper dried and pulverized, then boiled in Water of Cinnabar, or Brasil Wood, and then dried, one lb.

Yellow Powder.

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

Green
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Green Powder.

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

Blue Powder.

Take of Saltpeter 8 lb, of Sulphur one lb, of the Sawdust of Linden or Lime Tree Wood boiled with Indigo and Brandy, then dried and pulverized, one lb.

C H A P. 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 lb, of Venetian Borax one lb; these Ingredients being well pulverized and incorporated together, let them be afterwards corned.

2. Take of common Gun-powder 2 lb, of Venetian Borax one lb, of Lapis Calaminaris 1 lb fs, of Sal Armoniac 1 lb fs; pulverize and incorporate them well together, and corn them as before.

3. Take of common Gun-powder 6 lb, Powder of live Moles calcined in a glazed earthen Pot 1 lb fs, of Venetian Borax 1 lb fs.

4. Take of Saltpeter 6 lb, of Sulphur 8 lb and 1/2, Powder of the inner Rind or Bark of Elder 1 lb fs, of common Salt burnt 2 lb. 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
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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. Exter. 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 Composalion 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. Furthermore, 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 Composition 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.

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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
blackens it, you may assure yourself that there is too much Charcoal among 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.
We call that, damaged, decayed, or weakened powder, which is much degenerated from its first vigour, and the strength it was in due 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 exhalas, 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 re-assumes 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 re-instate 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, 1/4 measure of salprotic, 1/4 measure of oil of sulphur, and 1/4 measure of camphire dissolved in brandy; this lixivium being strained through a coarse strong scarse, 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.

The
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 lb, 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.

C H A P. XIX.

Of Buildings and Magazines for the preserving of Gunpowder, together with several Observations on the flowing, 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 Enterprises 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
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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 Inconveniences 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 Magazine 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 Morais, 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
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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 plastered either within or without, the Lime or Plaster 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 referred. 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, Canvases, 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 Wind-ing 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 Storekeeper'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 preferred upon the Floor of the second Story.

In Fig. 17. you have the Ichnography of a Powder Magazine, after the Design of Eugenius Gentilinus an Italian, who has very curiously represented one of this Nature in Chap. xlv. 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
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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, EG, IL, OP, PH, HQ, QN, and MK; 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 TU, in the Exterior Wall, and the Inward Breadth RS 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
at Pleasure: Nevertheless I would have every body to follow the In-
struction and Method of this Author, whose Name I have already men-
tioned. This is what I had to say of the Constructure 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 Pre-
paration, 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 Salt-peter 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 Scarce for its particular Use.

3. Your Ingredients shall not be mixed till they have been first well
dried, ground, and seared separately; which done, they shall be well
ground, incorporated, and seared 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 lb, or thereabouts, with
Covers of the same, well luted on the Outside with Glutinous, Bitumi-
nous, or any Tenacious Matter, to prevent the Air, or any outward Ac-
cident 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 gen-
erally begat Taint and Purreffaction in Flower. And furthermore, 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 Va-
pours, which are of hurtful Efficacy to the Human Body; and we may reaon-
reasonably infer, that as Saltpeter is extremly 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 repel 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 it,
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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 Gunpowder 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 ascend the Saltpeter than any other Fire whatsoever: But as Saltpeter being once inflamed by it, is instantaneously raised 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 burnt, 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 Gunpowder is, must not only be very susceptible, 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 ascends 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.
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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 relentless Expansion, and in this consists all the moving, expansive, 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 Gunpowder 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.

C H A P. XXI.

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

TAKE $\frac{1}{16}$ lb of common Aqua-fortis, dissolve in it an Ounce of Sal Armoniac, or as much as a little beat 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 Efluvescence) 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
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In such a case you must drop a little more of the Oil of Tartar into it; and be thou wise at my Ex pense: 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 Maris; or to do it with the more safety put it into a Glass Basin, 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 again: 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 devoluted 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 Muskett, 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 Defcend; 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 ascending 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 Contrary 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 Confitatis 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 acts upon each other just as the common Sulphur and Saltpeter do. It is of this that Quercetanus and Sennerus speak in a certain passage, (according to Joh. Jonstonus Adm. Nat. Clavi. 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.
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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 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 Corner) 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
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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 lb, 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 Ressemblance 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 eæ Oapura, ne bitumen credas, sicuti succinum bitumen creditis, &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-fide 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 Röhn, Oil and Frankincense, and such like Things. Again, he says a little farther, Camphorat vero cum sapientum maxima pars, frigidissimam statuat, Aenrois 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 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 Cofoalgent, heat 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 mislaken. 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 Oiliary.
nefs. Sure Folly is either the Mother or Daughter of Ignorance; for who would affirm that Things which are by Nature the botte$t, 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 moth 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 burfts the Rind or Bark and forces a Passage out, where it is concreted, and looks at first like Ropm, 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, Majick 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 Admtr. Nat. Clm. iv. Cap. ix. Scribunt Mauri Camphoram lacrymam eXe 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 spongy 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,
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To this I shall add, that it will be very easy to pulverize Campbire for the Use of Artificial Fireworks, if it be ground and pounded gently with Sulphur in a Mortar. The Oil of Campbire, 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 Pettle of the same Metal, till all of it be turned into an Oil of a greenish Colour. Or, if your Campbire 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 Campbire will then yield you a fine, clear Oil, which will burn with admirable Sprightlines.

CHAP. XXIV.

Of Water of Sal Armoniac.

TAKE of Sal Armoniac \( \frac{3}{1} \) j, of Saltpeker \( \frac{3}{2} \) 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 Naptha or Petrol, and Turpentine, of Quick Lime, Mutton Suet, and Hog's-Lard, an equal Quantity of each, then heat 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 Saltpeker; 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 Ebulition, 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.

C H A P. 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 confume 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.
C H A P. 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; firing 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.

C H A P. 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 flower, 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
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who add a little Gum Arabick or Tragacant to the Brandy, particularly when they would have it stick fast to any thing.

Francis Joachim Precbtel, 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 Mash 2 Parts, of Colophonie or Fine Resin 1 Part, of Wax 1 Part, of Salt petre 2 Parts, of Charcoal ½ 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 Sapientiae or Lute.

TAKE what Quantity of Loam you want, and dry it, beat it, and scarce 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 Glafs 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.
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 Mallow, 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 myself 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 second
cond Day; but afterwards you may do it; for these Accidents are sometimes cured by Perpiration only; according to *Leonardus Bottalus de Vulneribus Sclopetorum*, Cap. xxi.

2. Melt Lard into $\frac{3}{2}$ j of Water of Morell, or Garden Night-shade, and $\frac{3}{2}$ 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 $\frac{1}{2}$ j, of Saltpeter $\frac{3}{2}$ 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 $\frac{3}{2}$ j, of Oil of Walnuts $\frac{3}{2}$ 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 lb. Boil them all with $\frac{3}{2}$ j 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 Conspicuous of a Liniment.

Again; take old Lard, melted by a Flame, and received in $\frac{3}{2}$ j of the Juice of Beet Root and Rue, of the Cream of Milk $\frac{3}{2}$ j, of the Mucilage of Quince Seed, and Gum Tragacant, or Dragant, of each $\frac{3}{2}$ s. Mix them well, and make a Liniment of them. *Josephus Quercetanus*, in *Libro Sclopetario*, tells us this is a good Remedy.

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**C H A P. 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 these 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 lb 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 lb; 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 lb of Gun-powder, holds only 2 lb of Char-
coal, 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
laid of Charcoal, must be understood with regard to Sulphur and Sal-
peter, each of whose particular Divisions may be marked upon the two
other Sides of the square Instrument abovementioned. This Instru-
ment being adjusted, may be used after this manner. For Example,
if you would measure 2 lb of Powder, lift up your square Instrument or
Scale by the Ring at the end of it, till No. 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 3½ Feet, and
its Breadth 4½ Feet. In the Body of this, at B, the Drawer C is contrived
to go in and out, which is ¾ Foot high, 3½ Feet long, and 2½ 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
Purposes, 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 grind-
ing 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 Rocchete, and the Greeks, Pyrobolis; which last Denomination does not strictly agree with what we understand by a Rocket; inasmuch as Pyrobolis properly signifies Tela Ignita, or Fiery Darts. The Italians call them Rocchete and Raggi; the Germans, Steigende Kästen, Raggen 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 wherein he animated the Man he had made.
BOOK III. Of the Great Art of Artillery.

fault 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, Chestnut, 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 verify 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 lb: the middling Sort, are such whose Diameters can admit Bullets from 1 lb to 2 lb, or 3 lb at the farthest; and those are called great Moulds, whose Diameters can admit of Balls from 2 lb to 100 lb.) 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 suppose that the interior Diameter of the Mould (viz.) A, B, is equal to the Diameter of a Leaden Bullet of 1 lb; 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 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 3 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 4 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
Of the Great Art of Artillery. Book III.

which shall be subdivided into other smaller Parts. Moreover from F to K you shall set off one Diameter for the Members of the Bafe. 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 Aa to R, and then down to T and U, is 1 ¼ 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.

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 ¼ 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 Lift of it 3; the Echinus reversed 7; the Lift of that 3; the Cymatium or Doric Gula-reversed 7; the Lift 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 Astrapagal 4; and the nether Ring or Neck of the Column 2: the Projectures of one and the other Lift 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 Lifts 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 Bafe and Pedestal of the Mould. The upper Thickness of the Mould as far as the Astrapagal is ⅔ a Diameter of the Orifice or 40 Parts, but the Lower Thickness of O, P, upon the Bafe 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 Bafe by that other Line E, W, upon E, I; the whole Bafe is 1 ¼ 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 Lift under it 2; the Doric Cymatium 6; the Reglet 2; the
Book III. Of the Great Art of Artillery.

the Tore 6; the Liftel 2; the Projectile of the Lifts, and the Semi-Diameters of the Echinus reverfed, 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 \( \frac{1}{2} \) of the Diameter of the Mould, and consequently 66 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 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 \( \frac{1}{2}, \frac{1}{3}, \frac{1}{4} \) 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.

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Chapter 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...
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 to-
gether (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 Prac-
tice. 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 se-
cond Part of his Pyrotechnics Chap. IX. faith, That the Mould of a
Rocket of one lb, ought to be the Height of 2 Fingers, and the Dia-
meter 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 ½ of a Finger both to
their Breadth and Height. From this Progression this confused Dispro-
portion will arise, That a Rocket-Mould of 17 lb will have its Diameter
in a fubduple Proportion to its Height; and the Diameter of one of
100 lb will be within a little more than ½ of its Height: Thus the Dia-
meter 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, ½ 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 ½ of a Finger; and
that the Heights of his Moulds are most sadly proportioned to their Dia-
meters: Upon the whole, I am perswaded that this good Man never made
any Rockets in his Days, that exceeded one or two lb; for it would have
been impossible for him to make such ill-contrived Things depart, or ob-
lige 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 lb ought to be 2 Fingers; for it being certain that 2 Fingers ex-
actly constitute the Diameter of an Iron Bullet weighing one lb of No-
remberg; it will follow, that the Diameter of a Mould of 100 lb will ac-
cording to his reckoning he 26 Fingers and ½. Now if we suppose this
Diameter to be that of an Iron Bullet, it ought to weigh 2326 lb
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 lb 13 Ounces. By this, any one may readily perceive the
wretched Mistakes Brechtelius has fallen into, and how absurdly he rea-
oned upon this Head; and consequently take care not to mind what he

† This is right. The French has it Subdecuple, which is impossible.
Book III. Of the Great Art of Artillery.

Johannes Schmidlapius is the second of those ancient Pyrobolists I shall mention, who lived some time before Brechteslius. 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 Lotb 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 Lead or Iron Bullets. However I have often tried, and found that Diameters increased after the manner he prescribès, observe the following Progression with regard to Leaden Bullets; (namely) the second Diameter containing \( \frac{1}{5} \) of the first, is exactly the Diameter of a Leaden Bullet of 3 Lots: The Third containing \( \frac{1}{5} \) of the second Diameter answers to that of a Leaden Bullet of 7 Lots; the Fourth of \( \frac{2}{5} \) of the third Diameter is equal to the Diameter of a Leaden Ball of 20 Lots: The Fifth containing \( \frac{3}{5} \) of the fourth Diameter is equal to that of a Leaden Bullet of one \( \frac{22}{7} \) Lots: The Sixth \( \frac{1}{5} \) of the fifth Diameter is equal to the Diameter of a Leaden Ball of 4 \( \frac{1}{5} \) 26 Lots: The Seventh \( \frac{1}{5} \) of the Sixth, to the Diameter of a Leaden Bullet of \( \frac{13}{7} \) lbs: The Eighth \( \frac{1}{5} \) of the Seventh, is the Diameter of a Leaden Ball of 35 lbs: And to conclude; the Ninth \( \frac{1}{5} \) of the Eighth is equal to the Diameter of a Leaden Bullet of 98 lbs. From what I have here been saying, it follows, that this Author has not ascertained any fixed 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 Lotb, 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 lbs: But you must take care that the Paper of your small Casks, 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 Pyrobery about 59 Years ago; and the other published his about 90 Years since. Amongst those of the latest Date, we find Dieguus 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 \( \frac{1}{5} \) 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
Of the Great Art of Artillery. Book III.

roboli of all those I ever read (without disparaging Adrian Roman, James Valbaye, 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 lb 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 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 lb, 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 1/4 Diameters: And is taken from the following Table, where 86 corresponds exactly with 20 lb; 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 lb, so 86 being 7 times repeated gives the Height of a Mould that is 6 1/4 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 lb. 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 lb, which if it be divided into 100 equal Parts, and with a pair of Compasses you take 1/4 7 of those Parts; a sevenfold Repetition of them will give the Height of a Rocket-Mould of 100 lb, and which will be 4 of its own Diameter minus 1/4 or 399 of such Parts as its Diameter is divided into.

From hence it is evident that I have not fallen into an Extremity 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

† Example: as 100 : 7 : : 57

\[
\frac{100 \div 192}{7} = \frac{3 \cdot 59}{100} = 400 - \frac{1}{4} = 399 
\]

Divisions of the Diameter.
manner of Brechtelius, nor laid down one universal Dimension of Height with respect to the several Diameters; nor always kept to 6 and 6; 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 \( \frac{1}{4} \) 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 Mifake 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.

<table>
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<th>A Table of Heights for great Rocket-Moulds.</th>
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<td>Pound Weights of Leaden Bullets whose Diameters answer to the Diameters of Rocket-Moulds.</td>
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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 \( \frac{1}{2} \) of the same Diameter; E, F, is the Solidity of the Base or Bottom equal to \( \frac{1}{4} \) of the aforesaid Diameter; B, P, or A, P, is the Capital of the Mould whose Members are reversed or go upwards: The Lift is \( \frac{1}{4} \) of the Diameter in Height; the Echinus reversed \( \frac{1}{4} \); the Reglet is \( \frac{1}{4} \); and in short, the sloping or inclining Cornice is \( \frac{1}{4} \). Q Q shew the Thickness of the Substance of the Mould; P P denote the Hollowings wrought in it, which must be wounded, or securely girt round with glued Cord, to prevent the Mould from splitting whilst you drive the Rocket: These Hollowings are \( \frac{1}{4} \) 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 lb, it must be but \( \frac{1}{4} \) of a Diameter, and in the rest till you come to 100 lb, it must be but \( \frac{1}{4} \) Diameter. This Cylinder must be crowned with an Hemispher, or half Bullet, whose Circumference is described from the Center N, and whose Diameter is equal to \( \frac{1}{4} \) 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.

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 Hemispher.

### C H A P. 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 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 ½ 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 ⅔ 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 Cage has acquired the Thickness of ⅔ of the Diameter aforesaid; notwithstanding that in the first Mould, Fig. 20, I have supposed this same Thickness to be ½ of the Diameter; for then it is necessary that this Rowler or Former should be ⅔ of the Diameter. But for great Rockets that are made of Wood, such as you see in Fig. 23, the Thickness K B, or A I is ⅔ 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 Wouding 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 ⅔ 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 Canvas Rockets; but for Wood it must be 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 Canvas Cases for Rockets of 20 or 30 lb and upwards, and after having wounded 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.

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 ⅓ 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 Café 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 Fig. 23, your Driver or Rammer shall be of the very same Dimensions with the Hollow of your Rocket-Cafe, or Coffin, and shall have a Cavity in it that
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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. 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 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-Cafe 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. 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. 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 Neck of the Cafe 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 presses with his Foot, as may be seen in Fig 34.

But for the choaking of great Rockets, you may use the Contrivance 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 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 Fig. 37: 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 choke them. There are other ways of choking 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 Choker either by a great Force or Weight. But as these Ways are out of Use, and awkward 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. 38 represents a Copper Plate for making a Charger, as you see Fig. 39. in Fig. 40. I have given it such Proportion, that its Length from A to Fig. 40. B is 1 ; Diameter of the hollow Cylinder of the Rocket; and its Breadth C D equal to 2 of the same Diameter; and have ordered it fo, 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 2 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.

In Fig. 39 you have the Representation of a Wooden Mallet with Fig. 39: its Handle. It should be made of some hard, heavy Wood, such as Elm or Birch Root; its Length or Height shall be 2 of its Breadth or Thickness, which shall be proportioned to the hollow Cylinders of Moulds after this manner. From 100 lb down to 50 lb, 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 lb, with a Mallet whose Diameter is equal to that of a Leaden Bullet of 50 lb. In short, all from 10 lb to 1 lb, shall
be driven with a Mallet whose Diameter is equal to that of a Leaden Bullet of 40 lb; and as for those from 1 lb to 8 Lots or 4 Ounces, they shall be driven with a Mallet whose Diameter is equal to that of a Leaden Bullet of 20 lb. Or to do better, and speak more plainly; all your Mallets from 100 lb to 10 lb 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 lb drive all other Rockets, down to 4 lb; and from 4 lb to 1 lb with a Mallet of 6 lb; and from one lb to 1 lb with a Mallet of 4 lb. In short, from 1 lb to 4 Lots, or 2 Ounces, the Mallet shall weigh 2 lb.

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 drying, and dying about in a subtle 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 dipping 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 scoured, 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 Constancy the Action of that Element may be restrained. But this, on the other hand, is apt to throw us into a great Inconvenience; 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 Extremes, 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 Pyrobolift 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 Subduple of the First. If you would know the Cause of this, consult the Mechanics, and they will satisfy 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 Velocity 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 intenity of the power of the acting body. But we shall in another place have occasion to trace out more particularly the causes of the rarification 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 architechts 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 hoisted up by means of a rope reaved through a pulley 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 lb, 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. Merfennus in his Hydraulics, ballistics 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 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 flipping. 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 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,
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 Pulley, the use of which you shall know hereafter. Fig. 44 represents the Pyr—Fig. 44. tecnic Knife. In short, in Fig. 45 you see several Tools distinguished by A B and C, for cutting, hollowing, and engraving all the Woodwork used in the Construction of Pyrobolical Machines, a great Number of which I shall give you in the following Books.

C H A P. 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 dealt 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 Imagination, 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 footy 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-
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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 Disingenuousness, and Malice of Heart! for left 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 Pyroboloy, 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 ineffimable 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 Assitance 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 Eflua-via 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 would 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 Pyroboloy, 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: *Rocchetæ quo majores fuerint, lentiori onerentur materia: quo autem minores fortiori.* That is; the larger Rockets are, the weaker and flower 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 neccessarily 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 quae unam libram, vel duas ad summum superant; non alligetur aliis materiis pulvis Pyrius. For great Rockets that exceed 1 or 2 lb 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 lb down to 10 lb, 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 lb down to 1 lb or ½ lb, 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 lb 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, Nonuple and Dupluple; 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 Flatulant Expansion — both these Expressions bear one and the same Signification; but this is most intelligible here, and Flatulant Expansion is more proper in the other Place.

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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 lb 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 64 lb.

Of Saltpeter 30 lb, of Coal 20, and of Sulphur 10 lb.

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 lb; 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 lb.

Of Saltpeter 30 lb, of Coal 18 lb, and of Sulphur 7 lb.
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From 20 to 18 lb.

Of Salt peter 42 lb, of Coal 26 lb, and of Sulphur 12 lb.

From 15 lb to 12 lb.

Of Salt peter 32 lb, of Coal 16 lb, and of Sulphur 8 lb.

From 10 lb to 9 lb.

Of Salt peter 62 lb, of Coal 20 lb, and of Sulphur 9 lb.

From 9 lb to 8 lb and 6 lb.

Of Salt peter 35 lb, of Coal 10 lb, and of Sulphur 5 lb.

From 5 lb to 4 lb.

Of Salt peter 64 lb, of Coal 16 lb, and of Sulphur 8 lb.

From 3 lb to 2 lb.

Of Salt peter 60 lb, of Coal 15 lb, and of Sulphur 2 lb.

Of one lb.

Of Gun-powder 18 lb, of Salt peter 8 lb, of Coal 4 lb, and of Sulphur 2 lb.

From 18 Loths, or 9 Ounces, to ½ lb.

Of Powder 18 lb, of Salt peter 8 lb, of Coal 4 lb, and of Sulphur 2 lb.

From 12 Loths to 10 Loths.

Of Powder 30 Loths, of Salt peter 24 Loths, of Coal 8 Loths, and of Sulphur 3 Loths.

From 6 Loths to 4 Loths.

Of Powder 24 Loths, of Salt peter 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, ¾, ½ to, ¼ of a Loth or half Ounce.

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

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

C H A P.
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 design'dly 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 fireworks 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
the Sacred Gift of Prophecy, or rather of Pseudoprophecy: 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 Gratias, what I purchased at so dear a Rate: And breaking Silence to oblige my Friends, and serve the Public; despising all the Reptiles 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 $ of the Composition or Matter wherewith they are filled, minus a Diameter of their hollow Cylinders. The Breadth of the Orifice at the Choak shall be $ 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 $ 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 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 lbs: Its Height, B C, is $ 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 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.) $ of the Height of the Rocket minus a Diameter of its hollow Cylinder: And its Breadth E P will be $ of the Diameter M B. The Upper Breadth of the above-mentioned Borer in C is $ of the Lower Breadth D E. In Fig. B, which is the Second, you have a Piercer for Rockets of 12 lbs or 6 Ounces. C is for those of 8 lbs or 4 Ounces. D for those of 6 lbs or 3 Ounces; and in short, E is for those of 2 lbs 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 Piercers of small Rockets down to $ lb 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 lbs) into Parts Cubically proportionate to it; as into Sub-duple, which is one lb: Into Subquadruple, which is $ lb or 16 lbs, 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 lb. 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 Lbs., 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. shows 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 allotted to the Borers. This kind of Piercer ought to be fashioned as you see in Fig. 23, where M L is its Length, and 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 \( \frac{1}{4} \) of the Diameter C D, and the Upper Breadth at Q \( \frac{1}{2} \) 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 straier and shallower ought the Boring to be, and on the contrary, that the weaker and flower it is, the wider and deeper must it be pierced. The Reason of this may be easily gathered from what we laid in the foregoing Chapter; for as a strong Composition in-
flames sooner than a weak one, the Rocket which is filled with too vio-
lent a Mixture, and has its Orifice too wide, would let in the Fire too
abundantly, and instead of departing, would be confumed in an in-
stant; insomuch as the Fire having too much room in so spacious a
Cavity to act in, would in a Moment possesse itself of all the Matter,
reduce it univerfally to a Flame, and would most commonly burst the
Cafe, or else after having mounted to a considerable Height, it would
at once difperse 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 pro-
portion to the Composition they are filled with; or else be assured that
your Labour and Expence will vanish in Smoke. Here then (Friendly
Reader) is what former Pyrobolists have fo induftriously and fo 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 fo far
tainted by it, as to imagine, they should greatly prejudice their Reputa-
tions and private Interests, if they communicated any thing they make
a Secret of, to fuch deserving and curious Persons as might have a Ge-
nius for this Science. They either do not consider, or do not know
what daily Experience teaches us; (namely) that a Thoufand ex-
tinguifhed 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 Loj 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 forefee, that thofe Triflers (they
deserve this Appellation both on the Score of their Ignorance and Mean-
spiritednefs) thofe 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 recolleét that
common and true Saying, Principibus placuisse viris vel maxime fat eʃ.
Thofe 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 elfe.

But let us have done with this Topic, and proceed farther on in the
Construction of Rockets, and fet 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 Cicer,
Of the Great Art of Artillery.

CHAP. VI.

Of Sky-Rockets that mount up with their Sticks.

SORT I.

The Rocket represented in Fig. 48, which we have already sup-Fig. 48. posed to be of 1 lb, has its Height A B 7 Diameters, in like manner as is its mould: But from this Height we must first retrench 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 1 Diameter must be cut off or allowed; and in short, for the Binding of the Head, you again take from this Height 1 Diameter, as may be seen in K I and A C; therefore the Height of the Composition and Report will be 5 1 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 suitable to its Size (as we have already cautioned you) from E to G, that is, to 1 of the Height E I. This done, cover it with a little Cap of Paper or Pateboard 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 Pateboard, 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-Cafe 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 1 of the Diameter of the Rocket. You shall fasten it to the Inside of the Cæs 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, fly up through the Cæs, 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 1 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 Cæs 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,
short, it shall be bound up close at Top, and then bored from E to F, to the Height of $ 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.

S O R T II.

Take a Rocket-Cafe whose hollow Cylinder is equal in Diameter to a Leaden Bullet of 10 Laths or 5 Ounces; let its Height be 4 and $ Diameter, and filled with a suitable 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 $ 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 Cafe, the Diameter of whose Orifice is equal to that of a Leaden Bullet of 24 Laths 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 $ Diameter of its Orifice, and artfully bored to 1 $ of the same Diameter, so that there may remain $ of a Diameter of solid Head. Cover this with a Cap as before, and upon that, Corn Powder to the Height of $ 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 Cafe of a Third Rocket of 2 lb, whose Height shall be to its Diameter as we prescribed in the Second Chapter of this Book, and fill it with a suitable Composition to the Height of 2 $ Diameters; you shall cover this with a Wooden Cap, whose Thickness and the Diameter of the Hole through the Middle of it shall be $ 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.

Observe here First, that the Necks of the two first Rockets do not exceed $ 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
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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 suitable 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 Cafe 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 \( \frac{1}{2} \) of the Diameter a c; and let the Bottom f g be \( \frac{1}{2} \) of the same Diameter, to which may be fastened a Leaden Bullet by way of Counterpoise. This Tube or Cafe 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 Cafe 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 Cafe. The whole being disposed after this manner, and the Tube filled as we have directed, well reinforced 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-Cafe is made of either the one or the other of them. You have a full and particular Representation of this in 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 Representation 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 i Diameters of its Orifice or hollow Cylinder; and cover it with a Wooden Cap, whose Thickness is i of the same Diameter; and over that, Corn Powder to the Height of i of a Diameter; and upon that, Composition to i 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 i 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 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.
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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 \( \frac{1}{3} \) 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.

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.

SORT IX.

This Ninth Sort of Rocket shall be prepared after the following Order: You shall first fill the Rocket with a suitable Composition to the Height of 2 \( \frac{1}{3} \) 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 \( \frac{1}{3} \) of the Diameter of its Orifice; upon which shall be a Layer of Composition to the Height of \( \frac{1}{3} \) 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 \( \frac{1}{3} \), and upon the said Composition Corn Powder to the Height of \( \frac{1}{3} \). 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.

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...
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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 Choke, 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.

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 Paste-board, 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 Cape that encompasses the Fig. 59. Rockets. Fig. 59 will fully instruct you as to this.

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 Equilibrium 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 Equilibrio, 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 Equilibrium 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
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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 take a Stick of so many Fingers in Length to your Rocket.

C H A P. 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 ½ of the Length of the Rocket, and their Breadth at Bottom shall be ½ 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 ⅓ or ⅔ of the Diameter of the Rocket.

In Fig. 63 I have given you the Representation of a little Conivance 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 defend 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 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 Equilibrio with the Rocket; in the same manner as we just now said of Wooden 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 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 suitable 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, and thrown into the Water. See Fig. 66.
SORTS II, and III.

These Sorts differ very little from the foregoing, whether in Size, or the manner of filling and having 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 Fig. 67. 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 Fig. 68. in melted Wax or Pitch like other Water-Rockets, but only dabbed over with a Liniment, made of four Parts of Lanseed Oil, two Parts of Bole Armoniac, one Part of Plume Allum, and half a Part of Ashes.

SORT IV.

The Rocket which you see represented in Fig. 69, must be prepared Fig. 69. 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 Chosk 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.

SORT V.

Fig. 70 represents a Rocket which is prepared after the same manner Fig. 70. 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 ascending 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.

SORT VI.

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

C H A P. IX.

Of Rockets that run upon Lines or Ropes.

SORT I.

Take two Iron Rings or a Wooden Tube to a Rocket filled with a certain quantity of Ounces of a subtile 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.

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 $\frac{3}{4}$. 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 of which must be bored. You must then choke 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 tie small Paper Crackers all round it. The Contrivance of this Rocket is very pretty. You have a Representation of it in 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 Chock 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.

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.
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 Pyrotechnist; 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 rectify 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 Bowler.

4. Their
4. Their Necks shall be well and firmlychoaked; so that neither the
Knots of the Cord or Packthread, nor the Folds of the Choak, may di-
late 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 Scarce seperately:
Then weighing them again, they shall be well incorporated together in
one Mafs, and mealed a second time, and passed through a fine Scarce 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 Moiture,
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 im-
regnated with a great deal of gros 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 Dire&ion
upon the Driver.

11. Your Rockets must be driven with Mallets of proportionable
Weight to their Size; with an uniform Succession, and an equal Num-
ber 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 Ca-
jes their Convexity shall be plain, that they may be the more firmly se-
cured in the Rocket.

13. Your Rockets shall be bored with a suitable 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 gi-
ven. 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 completed, 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 choose some temperate Place.

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

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 suitable 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 Rocks are; which must retain in general (as much as possible) a Pyramidal 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.

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

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.

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 Campbire 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 Ammoniac, 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 Scrapings 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 Loadsstone 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-
BOOK III. Of the Great Art of Artillery.

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 left 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 Real Part, yet arrogantly take upon them right or wrong to censure the Performances of those who are incomparably more knowing than they are, with an envious Design of wounding their Reputation, or blustering their Honour, or to infilt a mean Opinion of them into those who are sometimes the most interested in the Laws or Conservation of the Persons so decried. But what can we say to these malicious Cenfors that may affront them less than that Old Saying: Ne Sutor ultra Crepidam, Let not the Shoemaker judge beyond his Lust. 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 Pyrobolick Art, than those who were well skilled in making Rockets; and accordingly not contented with caring 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 Warlike 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 Pyrotechny. 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 Oldenburg, 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
Book IV. Of the Great Art of Artillery.

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 suitable 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 Foetus in the Womb, which from Infancy advancing by degrees to Puerility, is thence gradually conducted to Virility, and at length completed 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.

E'T 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 \( \frac{1}{4} \) 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 \( \frac{1}{2} \) of the Diameter A B, and the Hollow of it G H shall not exceed \( \frac{1}{4} \) 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.
SORT II.

This Ball, which you see represented in Fig. 81, differs from the a-Fig. 81, bovementioned no farther, than that the Form of it is not Spherical but Spheroidal; 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.

SORT III.

You shall get an hollow Wooden Cylinder, made by a Turner, of the Fig. 82. Height A D or B C, which shall be 1 \( \frac{1}{4} \) of the Breadth A B or D C; it shall at Top be stopped up with a Wooden Tompion with a Hole in the Middle of it, of a Conic Form to hold the Priming, the inferior Breadth of which E F, shall be \( \frac{1}{4} \) of the Height of the Globe, and the superior Breadth of it G H, \( \frac{1}{4} \) 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 \( \text{Æolipile} \), 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 foldering 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 \( \frac{1}{4} \) 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 beimmered a little till the \( \text{Æolipile} \) 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 \( \text{Æolipile} \) 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 \( \text{Æolipile} \). Having done
all this set fire to the Priming with the End of a Match, and when the Composition is ascended and got to a strong Head, throw it into the Water; and in a little time the Fire issuing from the Vent heating the saltpile 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 Binsehwurm. 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 Profile 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 Tampion 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. Furthermore 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 pasted
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paste Paper, or of Canvas's 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 Profit of this will fully instruct you.

Sort VII.

Get a Wooden Globe that is perfectly Round and Hollow within, and Fig. 86. 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 thruf 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 furmounted 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:

Sort VIII.

The Form of the Globe in Fig. 87 is not Simple in its Construction Fig. 87. like the foregoing, but is pretty Complex; for its Lower Part is an hollowed Cylinder, which is furmounted 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.

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
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Or convex surface of it is fluted or hollowed in several places, for the more conveniently fixing of crackers to it. Those 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 shows 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 \( \frac{1}{4} \) of the breadth of the whole globe, and that its height should be \( \frac{1}{2} \) of its breadth. Secondly, that the water-ball B shall be as we ordered in the first sort, and on all sides encompassed 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 passage.
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Page to the Crackers when the Globe is blown up. In short, the Chamber D in the Part where it is broadest ought to be $\frac{1}{6}$ of the Breadth of the whole Globe itself, its Height shall be $\frac{1}{4}$, but underneath it will be sufficient if it is $\frac{1}{4}$ 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 $\frac{1}{4}$ 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 ascend 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 enveloped 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 represented in Fig. 92, is by the Germans called Waffer Pumpe, by which they mean a Pump or Pipe, or any such Hydraulic Contrivance; they again call it Waffer Morfer, 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 Tarry, 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 Crevices 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, a Water-Ball as you see in G; upon that, flow 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 flow Composition, then Corn Powder, and then a Light Ball as may be seen in I. Over this you shall a third time put flow 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 Cage filled with an Aquatic Composition. In short, to conclude, you shall fill the Remainder of the Tubes with flow 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 a 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.
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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 Orifice 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 fluid 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 3 iiiij, of Storax Calamita 3 j, of Frankincense 3 j, of Majic 3 j, of Amber 3 is, of Civer 3 is, of Sawdust of Juniper 3 ij, of Sawdust of Cypress 3 ij, and Oil of Spikenard 3 j; make your Composition of these according to Art and the Method laid down.

Or else take of Saltpeter 3 ij, of Flower of Sulphur or Brimstone 3 j, of Campbire 3 is; of the Rapings of Yellow Amber finely pulverized 3 is;
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of Coal of Lime-Tree-Wood $\frac{3}{3}$; of Flowers of Benjamin or Aafa Odorata $\frac{3}{3}$ fs. 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 lb; of Sulphur 4 lb; of the Sawings of Wood that have been previously boiled in a Saltpetreous Lye or Water, then dried, 4 lb; of good Corn Powder 1 lb; of the Shavings of Ivory $\frac{3}{3}$ iiij.

II.

Take of Saltpeter 6 lb; of Sulphur 3 lb; of Meal Powder 1 lb; of the Filings of Iron or of Hammer-saw 2 lb; and of Greek Pitch 1 lb fs.

III.

Take of Saltpeter 24 lb; of Meal Powder 4 lb; of Sulphur 12 lb; of Sawdust 8 lb; of Amber Powder 1 lb fs; of Glazi coarsely powdered 1 lb fs; of Campbire 1 lb fs.

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 Experience, 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 faith in Lib. VII. Cap. X. of his Physics, Ex particularibus praecognitis 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 accidented, and burning more outrageously 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.

Salt-peter 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 Eagernefs 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 intimate 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 Campbire, 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
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experience find, that without the help of any other Ingredient it burns in the midst of the Dampet 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 subtle Fat Substance. From whence happens that strange and admirable Phænomenon, that if you throw some Camphire into a Bafon 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 Subtilty 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 Rasplings 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 conseqently 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 blowes 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 Refolution 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 Glafs, being heated by the other Ingredients which are more combustible than they, are blown aloft by the Strength of the Powder and Salt peter, where appearing
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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 contends 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 Impetuosity 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 Pyrologist, 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 Sovereignty.

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. Hist. 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 shake still expostled bis Adversary's Assault. At first (the Story says) the Fire animated by the Sight of so mighty a Coloss,
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... laid bold 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 overthrew 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 disappoifted with the Combat, and from that Time forwards forbidding 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. æq. 7. eur. æq. 6. etc. de Indentibus Humido, Prop. 3, 4 and 7.) where he speaks of Bodies immerfed in Water, That Solids of equal specific Gravity with Water, or any other Liquid, being immershed into it, will remain susended 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 immershed 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 immershed, presses upon the Surface beneath, with a Pressure equal to that of a Bulk of Water as big as itself. Thus the immershed Part of a Water-Globe bears such Proportion to the Whole of it, as the Weight of
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 lb, and let \( \frac{1}{3} \) of it be immersed in Water, and \( \frac{2}{3} \) 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 Magnitude in the same Proportion as the immersed Parts of it are by the Whole, namely by \( \frac{2}{3} \); and thus a Bulk of Water equal to the Water-Globe must weigh 4 lb. 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 \( \frac{1}{2} \) of its Height, it will be evident that such a Ball or Globe will be \( \frac{1}{2} \) lighter than such a Bulk of Water. That is, that a Body of Water containing \( \frac{1}{3} \) of the 4 Parts of the Ball, will weigh as much as the whole Ball. Now if these \( \frac{1}{3} \) Parts of Water equal to the \( \frac{1}{3} \) Parts of the Water-Globe are called 3 lb, we may safely conclude that the whole Water-Globe weighs 3 lb 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 Equiponderant 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 Uncias (which is 729) to the Solidity of the Globe in Cubic Uncias or Inches; according to the Demonstrations of Christopher Clavius, Geomet. Prat. Lib. V. Fol. 253. From this Operation you will have about 381 Cubic Uncias, 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 Uncias, 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 Uncias 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 Uncias, or thereabouts. This Capacity of the Hollow of the Ball, which is 179 Uncias, being subtracted from 381 the whole Contents of the Globe (which we at first supposed to be Solid) you will have a Remainder of 202 Cubic Uncias, 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 Hemisphère upon the Tompion which stops up the Orifice of the Globe; which you may find out after this Manner.

Double the Plane of the Bafe of the Hemisphère, which shall be 3 Uncias and \( \frac{1}{2} \) square, or 42 Lines, and being doubled, you will have 7 Uncias square or 84 Lines for the Convex Superficies. In short, multiply this by \( \frac{1}{2} \) of the Diameter of the Bafe of the Hemisphère, and your Product will be 336 Lines for its Solidity, which are \( \frac{1}{4} \) 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 Uncias or Inches and \( \frac{1}{2} \) 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 Uncias ought to weigh 8 lb; therefore as the Cube of the Diameter of a Ball of 8 lb 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 lb, 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 lb, 8 Ounces, or thereabouts.

Let
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Let the Composition which fills the Cavity of the Globe be here supposed to weigh 8 lb, 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 lb, 11 Ounces, 7 Drachms, and 12 Grains.

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 lb Menstrual, and but 66 lb 8 Ounces Ponderal. Furthermore, we have from the Observations of Dogen agreed, that the ancient Roman Foot was equal to what we call the Rhenish Foot; and therefore a Cubic Rhenish 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 Unciae or half of the Rhenish Foot (the Water being taken out of the Rhine near Leyden in Holland) weighs about 8 lb 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 lb of ours. And because on the other hand a Cubical Foot containing 1728 Cubic Inches weighs also 69 lb; 381 Cubic Unciae or Inches, which are contained in a Bulk of Water equal to the Water-Globe we are now treating of, must weigh 14 lb, 5 Ounces, 2 Drachms, and 8 Grains; 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 lb, 11 Ounces, 7 Drachms, and 12 Grains, and that of a Bulk of Water equal in Magnitude to the aforementioned Water-Globe; which we have found to be 14 lb, 5 Ounces, 2 Drachms, and 8 Grains; and by subtracting the Letters of these from the Greater, we shall have a Remainder of 3 lb, 9 Ounces, 2 Drachms, and 20 Grains. Now as this is exactly the 4 Part of the aforementioned Bulk of Water; we must conclude that the Water-Globe is 1/4 lighter than the Water; and consequently, that the 4 Part of the Water, of equal Magnitude with 4/3 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 4 Part of the Weight of the Bulk of Water, which is 3 lb, 9 Ounces, 2 Drachms, 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 passes, 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 faith, *Lib. II. Prop. 33. Hemisphærii Centrum gravitatis sit punctum illud, in quo Axis dividitur ut pars quæ ad verticem fit 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 1/2 Lines, or the Axis of the Hemisphere, or 33 1/2 Lines, or 2 Inches, 9 Lines and 1/2 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 extravse postasum circa quod undique Partes æqualium momentorum confistunt; ita ut si per tale Centrum, ducat planum figaram quomodoque 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 æquiponderant, 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 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 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 Pyrobolus, 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 immerfed 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 Merfennus, 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 filed 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 immerfed 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 immerfed into, as also the immerfed, or emerged Parts of it. Let then the Part immerfed 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 immerfed 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.

‡ 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.
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You may by another way determine the Gravity of Bodies lighter than Water, (namely) by superadding a Sub stance that is heavier than Water, such as Lead whose Weight is known, and which by its Gravity immerses 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 to 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 supposethe Weight of the one and the other immerged Body to be 16 Ounces 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 immersed 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: To this Accident may be easily prevented by coating the Body well over with Wax, Pitch, or any thing of that Nature; for by subtracting 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 furthermore 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
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by Nicolas Tartaglia, intitled, Ragionamenti de Nicolao Tartaglia: Sopra la sua travagliata Inventione. With another intitled, Regola generale da fulevar er 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 Fig. 93. 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.

SORT II.

Get a solid Wooden Ball made as Round as possible, and coat it well Fig. 94. 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 not 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 that
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 Chock 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 left in turning, running, and winding about, they should be torn from each other; whereby your Labour and Ex pense 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 Scene-ographical 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.
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 \( \frac{1}{4} \) shall remain for the Diameter of the Globe you intend to make. You shall then divide this Diameter 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 \( \frac{1}{2} \) or half of the Height or Breadth of the Globe. The Thickness of the Wood H I shall be \( \frac{1}{4} \) of the above Diameter; but the Thickness of the Cover A K shall be \( \frac{1}{2} \) of the Diameter of the Globe. The Diameter of the Cavity G H of this Globe shall be \( \frac{1}{2} \) of its whole Diameter. The Height of the Priming-Chamber B F shall be \( \frac{1}{2} \) and \( \frac{1}{2} \) of the Diameter; but its Breadth \( \frac{1}{2} \) only; that is, its Height shall be \( \frac{1}{2} \) of its Breadth. As for the Diameter of the Touch-Hole, it will be sufficient if it is \( \frac{1}{2} \) or \( \frac{1}{4} \) 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 Pafted 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 new 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 sub stance. 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 up on 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 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.

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 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 composition
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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.

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 Cages: 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 aboveaid Channel then, you shall place your Cages 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 Cages ought to be placed upon the hollowed Berm or Ledge. The rest may be readily comprehended by whoever rightly considers this Fig. 101.
SORT VII.

You shall order a Wooden Globe to be made whose Height is double 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 $\frac{1}{4}$ of the Diameter of the whole Globe; and the Touch-hole shall be $\frac{1}{6}$ or $\frac{2}{3}$ 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 Pyrotologists 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
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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 Walntsbein) 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 Constrain. 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
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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 incommode 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 Aesculapius nor all his Successors of the Faculty, can find one Remedy throughout the whole Extent of their Science to repair the least Mischap that might befall 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.
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Take of Crude Antimony 2 lb, of Saltpeter 4 lb, of Sulphur 6 lb, of Colophone 4 lb, and of Coal 4 lb.

Or else; take of Antimony 1 lb, of Saltpeter 1 lb, of Sulphur 1 lb, of Colophone 1 lb, of Coal 1 lb, and of Black Pitch 1 lb.

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 1 lb, of Sulphur 3 oz, of Powder of Yellow Amber 3 oz, of Crude Antimony 3 oz, of Meal Powder 3 oz.

Or else; take of Sulphur 3 oz, of Saltpeter 3 os, of Powder finely mealed 3 os, of Olibanum or Frankincense in Drops of Mastic, of Crystal, of Mercury Sublimate, of each 3 os, of White Amber 3 oz, of Camphire 3 oz, and of Antimony and Orpiment of each 3 os.

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 Casd, and if you would rather choose to have them Yellowish or inclining to White;
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Take 3 iii of Gum Dragant, or of Gum Arabic, beaten, mealed and passed through a Searce; of Camphire dissolved in Brandy 5 ij, of Salt peter 1 lb 1/2 s, of Sulphur 1 lb 1/2 s, of coarse Powder of Glass 3 iii, of White Amber 3 1/2 s, of Orpiment 3 1/2 s: Incorporate all these Ingredients together, and make Balls of them as before. I learned this of Claud Migeorge.

The Method of making Sparks is as follows: Take of Salt peter 5 1/2 s, of the same melted 3 1/2 s, of Meal Powder 3 1/2 s, of Camphire 3 1/2 s. 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 Salt peter, then dried and spread out, and throwing it into this Composition, mix and stir it about, till it has absorbed it all. This done, roll it up in Pills about as big as a great Pea, which you shall let to dry after having salted them with Meal Powder. Use these according to our Directions.

We have, furthermore, a Way of preparing certain Odorous Pills, which are used in little Pyrotechnical Machines and Contrivances, which are fired in Rooms and Closets. These are commonly composed of Stoe-rax Calamita, of Benjamin, of Gum Juniper, of each 3 1/2 s; of Olibanum, of Majic, of Frankincense, of White Amber, of Yellow Amber, and of Camphire, each 3 1/2 s; of Salt peter 3 iii, of Lime-Tree Coal 3 iii. 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 \( \frac{1}{2} \) of an Ounce of Gun-powder. As for Example; if your Recreative Globe weighs 40 lb, you must, to dislodge it, allow 40 - \( \frac{1}{2} \) 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 Losts 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 Fig. 104. 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.

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, insomuch 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.
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Find out the Height of the *Powder* between *c* 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 *c 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 Inconvenience, the ancient *Pyrobolists* contrived Chambers in their *Mortars* which are as it were little Magazines for keeping the *Powder* close together,

\[ G g g \]
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 ob-
served, 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 Salt peter
in it; wherefore it was necessary that their Chambers should be propor-
tionably large. This, the Modern Pyrobolists have altered; for in our
Days, that Mars seems to have been more insolent and outrageous than
ever, those who have had the ordering of the Artillery have greatly lef-
fened 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 Gun-
powder, in proportion to the Capacity of the Chambers where such Ef-
fects 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 cer-
tain that the Air so condensed being let at liberty, would rush with
much more Noise and Impetuosity 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 Quan-
tity, &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 Gun-
powder 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
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manner of Restraint, and having forced a Passage to the Air, it violent-
ly 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.

W e 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 Ger-
mans call die Schleuge: One Sort of them being used in Recreative Fire-
works; (which only I shall here treat of) and the other is applied to Se-
rious 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 Repre-""
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Place, that it may contract a little Moifure, 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 foldered 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 Pack-thread 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 applied 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 Tetrabe-dron, others of a Prism, and in many other Shapes Regular and Irregular.
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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 Pyrobolists with all the Perpiciuity 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
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up the Palm of the Hand; for they are usually of the Size of an Iron Bullet of 4, 5, 6 or 8 lb. They sometimes weigh 1 lb or 1½ lb, and sometimes 2 or 3 lb. They are called Grenado's from the Resemblance they bear to the Punic Fruit which we call Pomegranates; for as the Rind of these includes 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 Gunpowder, 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 und 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 applied 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 among 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 Unce or Inches, and whose Thickness of Metal is 3 Lines. They are filled with Gunpowder, 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 burning 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 failing 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 favour more of Pyrotechnics than of History.

* This is the same with African and Carthaginian.
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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 alloyed 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 lb of Copper with 2 lb of Tin and half a lb of Marcasite; or else it shall be one lb of Tin, with 3 lb of Lattin. Those which are made of Iron, shall have their Metal throughout, of the Thickness of $\frac{3}{4}$ of their Diameters. Those which are made of Brass shall be $\frac{2}{3}$. And those which are made of Glass, shall be $\frac{1}{4}$ 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 $\frac{1}{4}$ of the Diameter of the Grenado; and the little Hole shall be $\frac{1}{8}$ of the fame 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 $\frac{1}{8}$ 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 $\frac{1}{4}$ of the same Diameter; and the Hollow of it shall be $\frac{1}{5}$, and the Top of it shall be a concave Hemisphere, as may be seen by the above said 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 Colophene, one Part of Turpentine, and one Part of Wax; these are all put into a glazed Earthen Pot, melted over a low Fire, and mixed and incorporated well together.

Compositions for the Fuzes of Grenado's.

I.

Of Powder one lb; of Saltpeter one lb; of Sulphur one lb.

II.

Of Powder 3 lb; of Saltpeter 2 lb; of Sulphur one lb.

III.

Of Powder 4 lb; of Saltpeter 3 lb; of Sulphur 2 lb.

IV.

Of Powder 4 lb; of Saltpeter 3 lb; of Sulphur one lb.
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 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 \( \frac{1}{2} \) 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 tie 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 Caloplone mixed with it; into which you may sink as many Muskets Balls as you please whilst it is cooling: Then wrap the Whole up in a Cloth, and bind it well round with Packthread.
BOOK IV. Of the Great Art of Artillery.

SORT III.

In Figure 111, I give you the Representation of a Hand-Grenado (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 Diagonally 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 Besieged have got to the Foot of a Rampart, and are obstinately bent upon infulting it, and insensibly scale it; (being covered by the Rampart itself from the Defences of the Flanks:) It is then that the Besiegers 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 is sometimes necessary to throw
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-loops, 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.

Buxtorf 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 Hulsh, and since then at Mureley, 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 awkwardly, 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
Book IV. Of the Great Art of Artillery.

and to carry their Contempt of them so far, as to burn them ignomi-
niously in their Kitchens, that there might not remain any Footsteps of
them; conceiving perhaps that their Successors, convinced of their In-
ocence, 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 wonder-
ful 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 Construktion.
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 In-
activity; 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 Caufe 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 won-
derful 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 Pyrobohatic Inven-
tions in present Use (which might be projected by the Sling, and Fundibali of the Ancients but not by the Balistæ) may be flung very conve-
niently to very great Distances.

First then; I beg of you to listen to what I am going to say of the
surprising Strength and admirable Effects of Sling, 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 jecus exaruit, quam cum Balearic Plumbum
Funda jacit, volat illud & incandescit eundo
Et quos non habuit, jub nubibus invent Ignes.

In English thus:

It burns, as when from Balearic Thong,
The ponderous Lead with nervous Force is flung;

† These were a kind of Sling.
Of the Great Art of Artillery. Book IV.

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 Leadens 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, spatique solutae
Aeris, & calido liquefactae pondera 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. Josephus 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

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* Lipsius Lib. V. Dial. seu Coll. XX. de Mil. Rom.
† Sen. Cap. LVI.
‡ Arist. de Coelo, Cap. VII.
‡‡ Diod. Sic. Lib. VI.

|| These are now called Majorca and Minorca.
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,
even though never so well tempered. An uncertain Author in Suidas, says of
the same People, That they flung 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 Liberal or Pound Slings. So much
for the Weight of the Stones they used to fling; 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 fling 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 furthermore a way of flinging
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 rais'd bigb Terrases
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 posseffed themselves of, says, That
there were Those who flung 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 far-
ther to this Purpoze in Julius Cæsar's Commentaries, where he says,
That a great Wind rising, the Gauls began to fling upon our Cabins and
Huts (which were only thatched with Straw after the Fashion of the Coun-
try) 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 Lippus is of
Opinion, that this ought to be rendered Earthen Vessels filled with melted
or boiling Matter. Oratius speaking also on the same Subject, says, That
they took red-hot Pots or Earthen Heads, and threw them at their Enem-
es.

It was thus that the Romans and the most Warlike Nations their Contem-
poraries used the Sling, as well in attacking their Enemies as de-
fending 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 Upfal, who was one of the most learned Writers

† These were Warlike Engines to shoot Darts or Stones.
‡ The ancient Inhabitants of Cadurcos 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 fling pieces of red-hot Iron, which they put into the Purfes of their Slings with Pincers. You always see them with a certain Vessel in their Hands made like a Roman Barrel, full of Cuts and Pieces of Iron, which being heated red-hot, and flung 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 Admixture it causeth in the Part. The Remembrance of an Event like this, is still fresh in the Person of Christian the IInd King of Denmark, who lost a mighty Army in the Year 1521, at the City and Camp of Arofen, 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 Ballifite (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 deafening Clap, and shivered all the circumjacent 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 be behold! Some were without Noses, others had left their Eyes, those their Arms, and those their Legs: In short, their Wounds being incurable, the Germans, Scots and Danes in particular, died in the utmost Miser.

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 ‡ Vegerius 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 flung. We read also in Holy Writ, || That among the In-

† Olus Lib. VII. Cap. VII. ‡ Veger. Lib. II. Cap. XXIII. || Judges Chap. XX. ver. 16.
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 attign'd to Fields and Grounds, which answer'd to the Caf 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 Caf. Those who know any thing of this Measure, affirm that it was 600 Foot. We find something to this Purpofe in Quintillian in loc., in these Words.

Fundum Varro vocat, quem poffim mittere Fundâ
Ni tamen exciderit qua cava funda patet.

But to what Purpofe 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 Intrainchments. First then it is a general Rule amongst our Military Architêcts or Engineers, to begin their Lines of Approach at the distance of 60 Rods from the Place Befieged; 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 likewife 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 ni
veau; 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 Toifes 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 Taizes only; who will deny that it may be very conveniently done by Sling? 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 1 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 right-angled 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 Hypotenuse, 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 above-mentioned; left 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 suitable 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 Marks-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 Virtualls till she shows him with a good Blow. But let us hear what Strabo says of these Illanders; 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 Balista 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 Balista 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 Profiles and Scenographical Figures of them, most curiously and exactly drawn, and occasionally explain how the Ancients were wont to contruet 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 faith, 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 Fille before it. And † Diodorus; Demetrius placed in his * Helepolis several Machines, the greatest of which carried Stones of three Talents. Abenazer also speaking of King Hiero's Ship which was built after a

‡ Joseph. Lib. VII. † Diod. Sicul. Lib. XX. * This nearly answers to what we now understand by a Battery.
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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 Baliste 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 Spheroidal; which last we commonly call Bombs. Though Boxbornius, 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 design'd 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 Counter-scars; 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 Pyrotechnics) I shall only observe that most Pyrotechnic-
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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 those Heroic Warriors, 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 achieved 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 infinuate 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 affuming 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, ⅓, ⅓, or ⅓ of their Diameters. The Vent ought to be ¼, 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 ⅔ of its Diameter in Length, though some Pyrobolists allow it but ⅓ only. Its Diameter at Top shall be ⅓ or ⅓, but beneath it shall be but ⅓ only. The Depth of the Concavity in the Fuze shall be ⅓ 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
BOOK IV. Of the Great Art of ARTILLERY.

Mortar is elevated to different Degrees of the Quadrant. It is moreover necessary to know 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 Pyrobolists: But let us proceed to the Sequel of this Essay.

These Fuzes shall be reinforced 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 suitable 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 found 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 subtract 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 subtracted 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 distinguished 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 Subtraction, 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 Piñol Powder as 144 does to 83. Upon this Foundation I have formed another Scale which you see distinguished by B for Fig. 117. 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.

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 straight 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 Foss, 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 Inconvenience (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 lb 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 lb: But from 100 lb to one lb, 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 Lols and 12 Grains, to Project a Ball of one lb. Upon this Foundation I have calculated a little Table of Proportion, from 100 lb down to one lb. There
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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 Lots; (for a Lot contains just that Number of Grains;) which Number of Lots 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 lb 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 Lots 8 Den. in the Quotient; each Denier 24 Grains. In short, these Lots being divided by 32, will give 3 ll. You must then take 3 lb and 8 Deniers of Powder to charge the Chamber of the Mortar, from which you would project a Body weighing 80 lb.

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.

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<td>5</td>
<td>573</td>
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<td>1</td>
<td>588</td>
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OBSER-
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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 lies 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 88, you will have 97 Loths, 4 Deniers and ½.

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 ½ to its Height; and you will have the true Height of a Wooden Tampion; 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 ½, and ram it with a Tampion of ¼. And in this Case the Rule we have given above can be of no Use.
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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 Fig. 118. 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.

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 Ascension 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 Fe-Fig. 119. male 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.

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 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 Perfons 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 Stratagem 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 Garrison of the Island of Trosel, 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 be 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 Watchendonk, 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.
Vive Le Roy
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foms 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 Conduit 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 horrid 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 melancholy Diversion!

This Author has hitherto pretty well informed us of the Place where our Millive Thunder was invented, and of the Time it was first put in Execution. But another Writer, who equally deserve 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 Harnef, 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 defected from the Duke of Parma, fled to the Confederates, to whom he pretended, that he had an admirable and unheard 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 burning, and besides, that the least Spark of them would instantly set fire to whatever they touched. But the Instant that our Grenadier was busy 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.
blistily 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 stripped 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 Brafi 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 Obstinance 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 Nighbourhood, 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 Deferrer, 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 Mis hap, 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. Sera. Lib. X. Decad. II.  ‡ This seems pretty obscure; but perhaps instead of Fuzes, they fluck some sort of Match in the Vents of their Granado's or Bomb's.
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furred 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 besieged, that the Inhabitants could hardly find Shelter from the Tempest, which continually purfued them where-ever they went, though they retired to Cellars and the most subterraneous Retreats. The Burgeffet 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 infenfibly lose their Country, resolved to go in a Body to Lanfeir their Governor, 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 bad but few Buildings left standing; and added, that if the Enemy continued to ply them with their Grenado's, it would be impofible for them to subsist, or make any farther Resistance, except they built a new Watchendonck 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 fo moving a manner of this dreadful Contrivance, that I could not help tranfcribing of him at length. It is from hence that the skilful Pyrobof is 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 thofe that are the moft obstinately bent upon defending themselves.

Here I fhould clofe 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 Pyrobofis, I think myfelf obliged to clear up every thing that may be obscure in relation to the Practice of our Art, for the Benefit and Instruction of thofe who particularly apply themselves to the Cultivation of it. Let us then look back to what we quoted from Faminus Strada, where he has feemingly defcribed the Form, the Properties and Effect 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 fpeaks of, since his Description of them agrees fo nearly with that fort of Arms which are now in Use with us. If he anfwers, that they were a fort of Balls, which in his Time were called Bombs; (which Word I know is promi-
cuously used to this Day) I fhall 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 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 Frontpergerus 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 leffer 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 + Olle or Fire-Pots are posterior to the hollow Globes which he speakes 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 Olle 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 moft 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 defist 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 affure 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 Caesar and Marc Antony, observes, * That Caesar 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 aemularias; but we must here conclude that Frumentius thereby means any sort of Vessels in general.
* Dion. Lib. L de Bel. A.D.
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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 Castricans 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 Fig. 121. 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.

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.
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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 abovefaid Direction, the Flints in the Barrel will by the superincumbent Weight of the Grenado be violently forced upwards, and consequently rubbing impetuoufly against the rough Inside of the Barrel, will strike such a Fire, as must ascend the Gun-powder in the Grenado through the Holes in the Sides of the Barrel, by which means it will have the fame Effect as the former.

C H A P. IV.

Of Grenado's that are shot from large Cannon.

I Shall now describe to you the fourth and laft 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 Clafs of these Grenado's, we shall give the first place to that which we have represented in Fig. 122, which (as may be seen) is Spheroidal 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 flow Compositions, which have been given for the Fuzes of Grenado's. Upon this Fuze, and the Socket which receives
receives 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 Equilibrio with it. This Equilibrium 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 sift 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 \( 2 \frac{1}{3} \) Diameters of the Cannon: Then clap on the aforesaid Conic Head, the Diameter of whose Bafe 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 firmerst 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 Sorts we have already spoken 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 Carrouches, 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 reinforced with an Iron Plate, and wrapped round by a strong Paper Cartridge; or else you may tie a little Canvas 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
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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 sur-
mount or rife 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 Profile 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 out-
wards towards the Muzzle of it. Though the Grenado be fixed in this
Pofture, 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 Chafe of the Gun be turned and whirled round several
times before it can reach the Muzzle; therefore it will be impos-ible 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 Po-
land 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 Archi-
medes 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 con-
veyed 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 Profile of this Gun with its Grenado
lodged in it, as may be seen in Fig. 129. As to the particular Propor-
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 forts 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 immovable: 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 ¼ 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 Jelt 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.

Thos 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. Thos 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-
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lifts (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 Boll-ledge, 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 myself, they could see nothing on all Sides but dead Bodies streched 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 inexplicable, 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 Bollledge and Breda, and who were careful Observers of every remarkable Occurrence that happened. First then, Daniel Heinfius, in his History of the Seige of Bollledge, speaks of Grenando'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 flung 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 Consernation; 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.

Boxbornius
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 Fortresses 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 Pyrobolik 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 Habitiaments, at the Feet of our Invincible and August King the Great Uladzs 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 caufe 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 Piaficus, Bishop of Premzlaw, 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
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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 Grenada'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.

C H A P. 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 Ognite Kule.

Since Fire-Balls are of a much elder Date than our Grenada'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 in intrinsic Worth, and more perfect than the former; Fire-Balls seem to have given up their Place, and to have yielded to Grenada's; and are accordingly grown almost out of Use. However, the frequent Services they have done rendering it indubitable, 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 Spheroïd, 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 Müfter) 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.

R r r

Spite-
Spheroid, or in Round ones as a Sphere; which must be afterwards filled with combustible Matter, and several Pyrophorical Compositions.

The Patterns for Spheroidal 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 letting it off upon some Plane, divide it into 4 equal Parts, as 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 ¼ 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 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 ¼ 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 Spheroidal 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 Spheroidal 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 bisected into two equal Parts, describe a compleat Circle round it, which you shall quadrisection 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 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 ¼ 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 Die-gus Ufanus’s Artillery; “Having taken the Diameter of the Mortar, inscribe it in a Circle, which being divided into Quadrants, by another Diameter intersecting the first at Right Angles through the Center 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 Equilateral Spherical Triangle. This done, cut out 8 Pieces of Cloth by this Pattern, and sew them neatly together, and you will have a Spherical Bag.” If you would now see the manner of sewing thefe Bags, cast your Eye upon Figures 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 lb; of Saltpeter 2 lb; of Sulphur one lb; and of Colophone one lb.

**Composition II.**

Take of Meal Powder 6 lb; of Saltpeter 4 lb; of Sulphur 2 lb; of coarse Powder of Glass one lb; of Crude Antimony 1½ lb; of Campbire 1½ lb; of Sal Armoniac one lb; and of common Salt 3 iiiij.

**Composition III.**

Take of Meal Powder 48 lb; of Saltpeter 32 lb; of Sulphur 16 lb; of Colophane 4 lb; of Filings of Iron or Hammer-slaw 2 lb; of the Sawdust
The Powder shall be first reduced to a very fine Meal for all these Compositions, and passed through a very fine Hair Scarce: 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 Cafe, 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 Pyrophatical Machines, which we shall speak to 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.
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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) shall be ½ of the Diameter of it; and that which is to be beneath shall be but ½ only: You have this in Letter A.

But I must beg your favourable Acceptance of what I have here taken from Brechetlius's Pyrotechnics, relating to this matter. " He says then, that for Balls of 100 lb, the upper Ring shall be 3 ½ Unciae or Inches, and the Lower one 3 Unciae only. For Balls of 75 lb, the Upper Ring shall be 3 Unciae, and the Lower one 2 ½ Unciae. For Balls of 50 lb, the Upper Ring shall be 2 ½ Unciae, but the Lower one 2 Unciae only. For Balls of 25 lb, the Upper Ring shall be 1 ½ Unciae, but the Lower one 1 Uncia only. For Balls which exceed 100 lb, as for Example, 125, or 150, or more; the Rings shall be increased half an Uncia for every fifteenth Pound. As for Balls between the Fifteenths, their Rings shall always observe a Medium, between 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 Thicknes, 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 Thicknes 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.

$ I f$ Now
Now to ease you of some of the Trouble you might be at in Lacing or Cording thefe 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 fee bent outwards, you may conveniently perform your Work. If you fhould sometimes happen, through too much Haffe, 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-Spikes, which you fee 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 fee in Fig. 149, or ſuch a Borer as Fig. 146. you fee 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.

Pyrobolıſts ūſually 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 Štages. 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 ¼ of the Length of the Firſt, and the Third ¼; 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 Štone Bullet weighing 100 lb, the Crackers ſhall be made of Iron or Copper Plates turned into Tubes, which ſhall be folded both without and within if poſſible, and their Orifices ſhall be re-inforced with a Ring of the Šame Metals. The Diameter of their Orifices ſhall be equal to that of an Ounce of Lead; and their Length ſhall be 6 of the Šame Orifices; I here mean the longest Crackers only; for the middling ſhall be but 5 ½ 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 obferve here, that the Leaden Bullets which are to determine the Diameters and Lengths of the Crackers for Fire-Balls of 25 lb, ſhall weigh half an Ounce: But for the reſt down from 20 to 15 or 10 lb (which are
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are the leafi 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. 143, 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 leaf, 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) complete 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 with. These Holes are made to facilitate the Reception 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 Pyromolists improperly call Tauff, and Einfkügel 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,
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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 Colophony, 1 Part of Linseed or Turpentine Oil, and melt and mix them well together in any large Brads 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 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 Spheroidal,) in the Bottom of which you shall fix 6, 8, or more Hand-Grenado's with very short Fuzes, which 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 Spherical Ball, such as you see in Fig. 139, 140, and 144, First fill it with Corn-Powder to 4 of it's Height, and let it be interspersed with 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.
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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 Interfices 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.

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 1/10 of the whole Diameter abovementioned, for the First Portion; 1/10 for the Second; 1/10 for the Third, and 1/10 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 Fig. 141. 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;
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 lb of Composition; the Second C will contain twice as much; and the Third will hold 3 lb. Thus these three, contained by and in each other, need only have 1 lb of Powder for every one in particular.

In short, the Fourth and Last would be sufficiently capacious to contain 5 lb 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 Last then shall be filled according to the Method prescribed for the foregoing: (viz.) You shall fill it to ⅓ 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 thee 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 **Maul 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**, (witnesses **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 **Æneas**. **VIII.** where he describes the Work on **Æneas’s Shield**.

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In summo cylios Tarpeiae Manlius arcis
Stabat pro templo, & Capitolia cellis tenebat ;
Romuleaque recens borrebat regia Culmo.
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In **English** thus:

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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.**
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**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 Muscovites were forced to deliver up themselves at Smolensko, by that Heroical and Magnanimous Prince Christopher Radziwille Palatine of Wiina, General of the Armies of the Great and Mighty Duxhy 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 flight 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 Poliorceticus; 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 Kin sect Fire-Balls which he threw into the Wooden Retrenchments of the Muscovites and Livonians: Upon which these 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 Canvas, 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.

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 fame 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 diffused, on the score
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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 \( \frac{3}{2} \) 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 Equilateral Triangle I K E.

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 cored 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 \( \frac{3}{4} \) 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
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 Bafe; (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 Bafe 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 Bafe 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 Bafe 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 Betti-nus Vol. III. Book III. in his Schol. upon Prop. I. of Euclid Book II and III, and in the following; as also in Theod. 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 straight 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.
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 reftified 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 infinuates itself into it, and changes the whole Substance of it.
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 exercising 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 shews) and which is Spirable, 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 Exercit. XI. Not only Attraction but Impulsion is caused by Rarification, as may be seen in Braes Tubes filled with Saltpetrous Matter; for the Fire in its Rarification 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 Elastic 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 condenze; 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 Condenzation, for it would not be condenzed near the Bullet, except from its First Ascension it was successively rarified. Thus is your Argument falsely grounded, and so ways metaphysical, and all from your Ignorance in what concerns the Moving Cause: Indeed this Denotation 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, Condenzation is a Motion by which their Bounds are contracted. Impulsion is a Promotion of the Extremes. Therefore you are mistaken, to attribute this Motion to Condenzation.

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 Balifæ, Scorpionæ, 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 Balifæ to Rarifaction. For it is performed by Condenzation; because whenever the Bow of a Balistra unbends it Condenzes. 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 condenzes; 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 Rarifaction-

† Scorpionæ 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 Conden-
sation; you should allow the same thing for Fire-Arms, in which the Rari-
faction is always Antecedent to the Condenfation. If a Bow be broken it is becaufe 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 Rarification. 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, becaufe whilft they have any thing that retards their Contraction, they are contracted with less Violence; but when they are devided 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 Respect, which cannot be done without Condenfation. It is a Return of the whole, but a Condenfation of Parts only. Truly this Motion is different only in Cause, and not in Effect. The Impulsion is a mere Effect, and the Condenfation a mere Cause. The Traction is the Cause of the Impulsion, and the Effect of the Condenfation. The String of the Bow is broken when it unbends without an Arrow, not for the same Reason that the Bow breaks (viz.) by Rarification, 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 Rarification.

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 Flame, 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 being violently and for some time beaten in a Mortar, it is greatly rarified and subtilized, by being deverted 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 needles 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 necessarily be finite, and circumscribed within certain Bounds. Thus Philo\-phers and Geometricians tell us, That a Super\-ficies 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. I. Sphaer. 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 Ico\-hedron, because of its great Mobility and Fluidity. To the Earth he allot\-s 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 Gu\-powder, 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 Chafe of a Piece of Ordnance, it must take upon it the Form of a Cylinder.
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 retards 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 Rapification) 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 Diminutive Line is exactly ¼, 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 weakened.

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
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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 Tampion 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 Tampion; I say, it is most certain that whatever Figure the Flash assumes upon its Ascension, it will impel and drive out the Tampion with all its Might, and that either of the Projectiles must equally share in the Impulse of the Tampion, though their Motion would be unequal, from the Inequality of their Figure, as shall be observed hereafter. What does it signify if the Tampion 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 separated 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
more obverse to you; that the more the Flashe is confined and restifled, 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 leaff Atom of the Moving Power or Flashe 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 Flashe 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 Ballista; 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 obstrucft and annihilate the Motion given; which Mersenius thus accounts for: † Whatever is produced cannot be destroyed, except it be attached 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 Restifying 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 affists 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

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† Merfen. in Phane. Ballist. Prop. XXXVIII.
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 forfake 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 Rarification, 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 Chafe 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 Chafe 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 affists 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 Pyrotechnists 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 Chafe of the Piece. I say then again, that the Flash which accompanies a Bullet through the Chafe of a long Gun can by no means add to its Velocity, for the longer it remains in the Hollow or Chafe 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 lb, which if it was allowed but the usual Requisite for such a Ball, which is 1 lb of Powder; I firmly believe that the Flash of such a Quantity, in accompanying the Bullet through so long a Chafe, 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 Merfennus 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 roll 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 alternately 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 rolls 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 inferring 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 Merfennus, 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
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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 revolved 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 completed 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 haften 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 Pyramid; 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, 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 above-mentioned, 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 \( \frac{1}{4} \) 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 flip down the Middling one, into which you must put the Leaft, 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 Leaft. Moreover, the Middling one as well as the Leaft 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 Bullets. You are to separate them from the Powder with Paper Wadd s; 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 Proofs 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 Crofs, 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.

C O R O L L A R Y III.

Of the several Sorts of Lacings, Mattings, and Ligatures of Fire-Balls, and the Terms suitable 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 Reihbont. The Second with its various Interweavings, which you have in Fig. 137, they call Fallen-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.

C H A P. 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 Artifi 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 Sestalateral 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 4 of the whole Diameter of it. This Fuze must be filled with one of the ordinary Compositions for Fuzes.

† I think this may as well be called a Thundering Ball, as a Barrel full of Grenado's is called a Thundering Barrel.
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The whole Body of it shall be filled with Hand-Grenados, 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 Grenados 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 Fig. 153 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.

1. You may take Balls of what Sizes you please; but the Thickness of their Shells shall (according to our Figure) be \( \frac{1}{2} \) 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 glue 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 Musquetiers 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 Ute 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 reinforced with such Iron Bandons as we formerly mentioned, to enable them the better to withstand the Shock of the Flash.

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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
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Fire-Rain, and which the Germans also call Feuer Regen. The Preparation or Confection of this is very common, and well known.

Melt 24 lb 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 lb 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 lb 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 taking them over with Meal Powder, put them into a Wooden Ball, (such as you see in Fig. 154, which must be of Fig. 154. the same Dimensions 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 Tarrred Cloth.

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 Geschmolzenzeug) you may use one of the following, which must be prepared in the same manner we just now directed.

I.

Take of Sulphur 3 lb, of Saltpeter 1 lb, of Corn Powder 1 lb, of Filings of Iron or Hammer-flaw lb 1/2, and of Powder of Glaeb lb 1/2.

II.

Take of Sulphur 1 lb, of Saltpeter 1 lb, and of Corn Powder 1 lb.

These two Compositions I have borrowed from Joseph Furténbach, 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 Cuiraś; 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
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III.

Take of Sulphur 3i, of Galbanum 3iiij, of Saltpeter 3iiij, and of Corn Powder 3iij.

IV.

Take of Sulphur 3v, of Saltpeter 3ij, of Colephone 3j, of Corn Powder 3ifs.

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 Powders 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 {o}v{e}p) Oil of Sulphur and Petrol; Saltpeter highly refined; Rosin of Turpentine, of Tar, Oil of Eggs, and sometimes to give it a Consequence they add Rapings of Lawrel or Bay; These being Set up in a Glass Vessel, must be buried under a Dungbil or a Dung-beat 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 1; 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. Bapt. De la Port. Lib. II. Cap. X.
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 lb, of Saltpeter 8 lb, of Crude Antimony 2 lb, and of Corn Powder 4 lb; 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 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 John Zonaras affures us it was invented before the Time of Constantine Pogonatos Emperor of Greece. Nicetas Choniates in Iaasio speaks thus of it. They threw among the poor Inhabitants 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 πυργαγός (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 Construction 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 Laurel or Bay, each Six Parts. Powder of Dhemest or dry Bays, and of Camphire macerated in Brandy; of each 1/4 Parts. Of Saltpeter, to the whole Weight of them all. Put all these into a Glafs Vefsel 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 signify no more than distilling it over a Fire.
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of another fort 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 Seminaurus 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, πετρελιανοῖς.

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 manners 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 confented:) 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,
them, they will burn without doing the least Damage to the Vessels which contain them, except they are very thin and light, 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 Cages, 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 ascended, 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 here-after) it must consequnetly 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 faith: † 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 Ignous Ingredients; for Ex-

† Joh. Bap. de la Port. Lib. II. Cap. X.
ample: Take of Camphire, of Sulphur Vivum, of Turpentine, of Gum Juniper, and Oil of the Yolks of Eggs; together with Tar; Powder of Colophione, 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 show hereafter) which Liquid shall be thickened 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 Confection. (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 Mycia, 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 roasted, and much heated by the Sun upon a very warm Day, and emitting very hot Vapours, the Window took Fire, which soon after got bold on the Roof, and in a little time spread all over the House.

The same Author faith in the same Place: That if you would make a Fire which shall be extinguished by Oil, and ascended by Water, you must confess 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 faith: That Water ascends violent Fires; because the Moisture it exhales is rendered more Fat and Greasy, and is not wasted or destroyed by circumjixed 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 accend 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.
BOOK IV. Of the Great Art of Artillery.

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 Asphalites 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 acceded 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 faith: † 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 acceded by Spittle, and was frequently used by Thieves and Robbers: (Pyrobolites 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 Loaditone, 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 Feces 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 inferred to evince how great an Enemy I am to Jugglers 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 dawbling 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 Naphtha. But if what Cæ. 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: Coeptis omnia sequiantur in equi ventre per mensis tres, in marginis scriptum suum, in equo satis ventre.
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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 Saltpetre, 2 Parts of Oil of Sulphur, 3 Parts of Water of Sal Ammoniac, 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 lb; of Sulphur Vivum 6 lb; and of Quick Lime 20 lb.

II.
Take 6 lb of Saltpeter; 4 lb of Sulphur; 1 lb of Frankincense; 1 lb of Linseed Oil; ¾ lb of Oil of Petrol; 8 lb of Gun-powder; 12 lb of Quick Lime; and one lb of the Juice of Onions.

The two following are from Freunberger.

I.
Take equal Portions of Copperas-Water, Sulphur, and Oil of the Yolk 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 Ruffel 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 several
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 to-
gether with Iron Wire, and lute the Juncțures well up, that it may be
impossible for any Air to infiltrate 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 Re-
netidum 1 lb, of Linseed Oil 3 lb, of Oil of Eggs 1 lb, of Quick
Lime 8 lb: 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 with.
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 Interjices between which may be filled up with one of these Com-
positions; taking care that these little Vessels or Cheests 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 Mix-
ture; 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 Cheests 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 un-
der the Surface of Water, you may find them in Mercenius in his Co-
roll. II. Prop. 49 of his Hydraulics, and in Book II. of his Art of Na-
vigation; 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.
Of the Great Art of Artillery. Book IV.

C H A P. 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, Rofi 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 Coat 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 Covering, and project it where you please. See Fig. 155, distinguished by Letters A and B.

SORT II.

Take of clarified Salt peter 1 Part, of Sulphur 1 Part, of Orpiment 1 Part, and of Pitch 1 Part, of Colophone 1 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 Petroleum 1 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 circumjacent 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 lb, of common Pitch 4 lb, of Colophony 1 lb, of Saltpeter 2 lb, and of Suet or Tallow 2 lb. Melt all these, and add to them 1 lb of Coal, and mix the whole very well together over a Fire; then take it off, and throw 3 lb 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 Colophony 1 lb, of Sulphur 2 lb, of Saltpeter 1 lb, of Coal 1 lb, 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 Ufanus, in Treat. III. of his Artillery, Chap. XX.) at the Famous and Memorable Siege of Osten, 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
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 Diego Ufianus Treat. III. of his Artill. Chap. XX and XXI, and in Hansel's Artill. Page 187 and 211, in Brechtelius Part II. of his Artill. Chap. I and IV; and Fronsberger's Artill. 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 full 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 Pyrotechnic Writers I just now mentioned, you may upon this Subject turn over Jerome Catmenus's Examination of Artill. Page 37. Jerome Ruffel'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.
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 Assults, 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 lb; of Tar 2 lb, of Colephane 6 lb, of Sulphur 8 lb, and of Saltpeter 36 lb: Melt all these Ingredients together over a Fire; and then add to them 10 lb of Coal; 6 lbs of the Sawdust of Pine or Fir, and 2 lb 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 Horror 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 curiously say that they are most deeply

† Here we must allow for the Prejudice and Superstition of our Author's Religion,
verfed 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 Re-celles 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 suitable 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 Pecopian Tartars, near a small Town in Podolia called Ocbanow, 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 Koniczpolski, 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 repose 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 Prolongity: 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 20,000, which is more likely, but the Table of Errata will have it 800,000.
lowing were none of the laft 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 Poisned 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 Ufe 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 Dis­ilu­teneis; 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 murdering 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 E c e e other
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 Scytches 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 Pauhs 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; Didoecrides Lib. VI. Cap. XX. In short, Virgil in his Æneid Lib. IX. speaks thus:

\[\text{Ungere tela manu, ferrumque armare veneno.}\]

In English:

\[\text{In Darts invenom’d, and in Poison skill’d.}\]

Dryden.

And in Lib. X.

\[\text{Vulnera dirigere & calamos armare veneno.}\]

In English:

\[\text{Directing Ointed Arrows from afar;}\]
\[\text{And Death with Poison arm’d.}\]

Dryden.
Book IV. Of the Great Art of Artillery.

And in Lib. XII.

Non secus ac nervo per nubem impulsa sagitta,
Armatam feri Parthus quam felle veneni,
Parthus seoe Cydon telum immedicabile torcit.

In English:

by far more flow
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 Odisy. I.

Pharmacum, mortiferum quarens, ut ei effet unde sagittas oblinere.

In English:

Seeking a deadly Drug wherewith t' infest 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 worfe 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 Soldiers. 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, (vix.)

† 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 even has, except it be outwardly infected by any poisonous Tincture, and that it can be infected no-body will deny: For I

† Io. Quercet. in Libello Scioparasio.
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 spongy, which is owing to its being compounded of impure and combustible Sulphur; and of much feculent and droph 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 Groftness by being purified, cannot admit any strange Body into it: Indeed Nature informs us, and Experience teaches, 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 disincumbered from all its Droffy 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 those 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 among the most solid Metals, may be mixed and tempered with a Substance quite foreign to itself? Who will assert that a Mixture of Vinegar, Soot, Water of Mouse-car, and of Earth-worms, mixed with the Juice of Raisins, is in any respect of an Iron's 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 ever 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 Metallic Spirits which are of the same Genus or Kind, cannot be more easily affected than this: For we see that Copper is tinged and turned Yellow by the Spirit of Calamine and of Tuitia; 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, Fetic and Deadly Waters, to which are usually added the Juice of Aconitum or Wolf-
BOOK IV. Of the Great Art of Artillery.

Wolf-bane, of Napellus, of the Squilla or Sea-Onion, of Eugh, of Smallege or Crow-foot, and such like Simplets, 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 Peltiferous, that if the Point of an Arrow be but slept 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 subtle 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 immersing 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 Subtlety of these Drugs!) infest the Wounds they make, though they should with the greatest Velocity pierce through the Body. This 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 showed above, the more subtle 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 consists in the lively proper Action of the Spirits. That Poisons are the most pernicious when they are the most subtle 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 Wulfperots; 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 F F F F Month
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 to 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 Basin 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 Nopellus White and Blue, Monk's-brod, Pasflower, Butter-flower, Poisonous Nightshade, Sea-Onion, and several other Simples of this Nature.

The following Things pulverized may do very well, (viz.) Mercury Sublimate, White Arsenic, Orriment, Cinnamon, 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-fisher, Diagredes, Colocynthis, Euphorbium, one and the other Hellebore, of Thymeless, 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 smoking 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 Hydraulics.
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 Pyrobolists; 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 Fœtid 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 lb of common Ship Pitch; 6 lb of Tar; 20 lb of Saltpeter; 8 lb of Sulphur; 4 lb of Colophony. Melt all these over a slow Fire in an Earthen Pot: And being melted, throw into them 2 lb of Coal, 6 lb of the Rasplings or Parings of Horse's or Mule's Hoof; 3 lb of Aëta Fœtida; one 4 of Sagapenum, which the Latins call Sacopenum Putidum; and 15 lb of Spatula Fœtida, or barking Gladwin: Incorporate all the above Ingredients well together; and add to them as much Flax or Hemp as is sufficient
BOOK IV. Of the Great Art of Artillery.

C O R O L L A R Y.

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 pestilent Vapours, arising from the stinking Effluvia of Carcass, the Putrefaction of rotten Carcasses, 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 Pamished 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 Carcasses of Soldiers, or any sort of Carcass; together with great Tubs full of the Emptings of Privies, and the like, which may be tossed into the Besieged Place. History will inform you of many such 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 Liegeois vigorously assaulted the Castle of Argenteau, throwing great Stones into it with Basin, together with Earthen Vessels full of melted Metal, Red-hot Iron, and Excrements in abundance.

From hence we may draw these Conclusions: Firstly, 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 Partly sooner than they designed.

Secondly (which is well worth our Observation) That by the Help of the Antique Machines, you may not only fling the Dead Carcasses 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...
Oft been by Philostratos O---ARTILLERY. Book IV.

of the Siege of Π τολεμαίος 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.

O SCIAl A E I A TA C R I T C ,

Atque eadem ingenti mutato ponderi telis
Ferram excutient orum media agmina ruptit.

In English:

--- Then from contracted Strings,
Stones of vast Bulk the Phocasian Engine flings,
Or changing Weight whole Trees with Iron bound,
Ejects, that breaking through, the Ranks confound.

Judge now of their Weight by their strange and frightful Execution. We moreover find in the Annals of Spain (according to Lippsius) a Story of a Young Man called Pelagius, who was a Person of great Modesty, and being earnestly solicited 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 putrefied Carcasses and an infinite Number of Vessels of all Sorts of Figure filled with Venous or Smoky Compositions, and all other Pyrobalical 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.
Of a Ball, which Fire-Workers call a Death's Head.

Take a perfectly round Ball, of Iron or any other Metal, of such Fig. 156. 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 \( \frac{1}{2} \) and the Breath of \( \frac{1}{2} \) 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.

The great Hollow in the Middle shall be filled with Meal Powder, to which shall be added \( \frac{1}{2} \) 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 Grenades. 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 Wadding 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 Fig. 151, 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.

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.
mid; which Pyramidal 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. Furthermore, 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.

C H A P. 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 recourse to, which is no other than a Bundle of Iron or Copper Crackers of Fig. 151. the same you see represented Num. 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 Leadén Balls, and bound firmly together with Wyre or Cat-gut, so that they may not be torn afunder 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 flow 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.
C H A P. XVI.

Of certain Pyrotechnic Balls which may be privately hid, and so ordered as to perform their Effects at certain Pre-fixed 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 forbade their Pyrotelists 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, Clofets, 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

H h h h

the
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 twirled 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 Ignuous 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 referred to herself a Power of putrifying, which is altogether surprising! For we find that the Animals generated from Putrefaction, 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 extremely 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 Paife.
Book IV. Of the Great Art of Artillery.

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 forefaid 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 Balistae 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 severall 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 expressly 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 Piascius Bishop of Premislau, 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 Ofianus gives us a Relation almost as Tragical as this, to which he adds an odd Accident that befell 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 Accidents. 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 Defector 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. Ueb. 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 faith 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 Ognisfe, to signify all those Balls which are contrived to burn Edifices, Intrenchments, Palisades, and other Wooden Defences of War, which answer to the Latin Expreflion Globus Ignus, vel Ignitus, or a Fire-Ball; this (though improperly enough) is applied to Red-hot Balls: Moreover, the Signification of the Latin Words Ignus, 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 Chafe 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 sponge 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 Chafe: 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 slipped 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.
C H A P. XVIII.

Of Pyrotechnic Hail, by which are meant Case Shot, or Cartridge 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 shot up in Wooden 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 ⅕ 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 Canvas 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.

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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.
All these will do terrible Execution in Skirmishes, Assaullts, 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, Herfes, Portcullices, Falcines, and all kinds of Wooden Defences and Coverts. In fine, they will serve to ruin, and overfet 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 Ingenios, 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.

K k k k
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, † Isdem Machinis sperant me restitutum posse labefactari, quibus ante astantem perculerunt: ‘They expect to subvert me by the help of the same Machines, wherewith they throw me down before from my Prosperity;’ here you are to understand the Word Machine to signify deceitful or malicious Efforts. Brutus also saith: ‡ Omnes adhibebat Machinas ad tenendum Adolescentem: ‘I leave no Machine unworked 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 Pieces, and other such like: Under this Denomination we might also range Musquets, Arquebusses, or (as they were formerly called) Mortarizing 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, Balifae, Catapultae 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 Turrentum, which is now used to signify our Cannon and Pieces of Ordnance; referring Machine for Battering Towers; Platei, § Musculi, running or rowling Towers, ¶ Sambucea, Tollenones, and all sorts of Scaling Engines or Ascents, and all those Things, under which we fixed the Tormenta beforementioned, and under which they covered their Soldiers when they attacked a Fortrefs 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, Pyramiđs, Obelisks, Colaflis, 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 aforesaid, 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. * Those were Engines forHooting of Stones. || Those were a kind of moveable Pent-houses or Galleries. § Those were much the same with our Galleries. ¶ Those were for scaling of Walls.
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 faith, † 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 Architecture 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 soft and ponderous Bodies; The Motion of which is artificially contrived by the Help of Wheels and other Circular Movements. The Scantorium or Scaling Machine is of one Sort, the Spiritale or Pneumatical Machine of another, and the Tractiorium or Draught Machine of a Third Sort. The Scaling Sort is adapted for Persons to climb up, by means of Crost 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 Organick 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, Transfums, Bindings, Joints, Buttreses and Props. The Wind Machines are capable of very notable Effects. But the Machinæ Tractioræ 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 Organick. 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 Prestes. And the latter on the other hand operate by the Light artful Touch of a single Person, as may be observed in the Projections of the Scorpiones and Anasicycles; therefore are they both useful in different Respects.

† 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.
Of the Great Art of Artillery. Book V.

Respects and Occurrences, and without them we should be oftentimes embarrased 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 Hories to move and transport them from Place to Place: But I must confess that Musquets, Pièces, and other Portable Arms might not improperly be called Organs, as well as the Scorpions, 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. Langenus, where he faith: 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 Pièces 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 Cages 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 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; Fig. 171. 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 Equidistant 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 Chiffel (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 Parallelipiped. 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
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 above-mentioned hollow Spiral Cylinder with Quick Match loosely twisted, or with a flow 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 come 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 Bos, or else project in a Spike or Point towards the Middle, and by means of the Bos 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,
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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 Fig. 173. 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.

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 Rhombusfidal. 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 abovefaid 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 aforefaid, (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.
SORT V.

The last Sort of Buckler, which you see in Fig. 175, cannot be per-formed 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 Bof 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.

CHAP. II.

Of FIRE-CUTLASSES.

Make a Cutlās of two Pieces of smooth dry Wood, after the Pashion 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 Profile 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 Innerfides of your Cutlās, 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 Cutlās, you shall coat it all round
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. Furthermore, 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-Epée.*
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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.

CHAP. V.

Of FIRE-POLES or RODS.

Your Fire-Poles shall be of the Length of 10 or 12 Foot, and of Fig. 179. 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.

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
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 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.

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Besides this; I here give you a round Wheel, of which is formed a Basin 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 Cape 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 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 Cape, 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 Casks 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 univerfally coated with Pitch, so that your Wheel being committed to the Water, that Element may not have the least Admittance into your Trains, Rockets, Cakes 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 Pyroboliff 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 cast 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.

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 Pyroboliffs 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 affiduous 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 Pyroboliff 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 lb; of Sulphur 2ij; and of Coal 3j; 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 Cutlafs it will do very well and is very fit for this purpose.
SORT III.

Get a Club turned with its Handle and a Spheroidal Head, and let Fig. 186. it have a Spheroidal Cavity within; 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. Furthermore, 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.

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 Cages upon a Rowler, which must be a little less in Diameter than the Cavities abovementioned; these Cages 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 these 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 Cages 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 lb.; of Sulphur 1½ lb.; of Powder 3 iii.; of Coal 3 i. 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.

C H A P. VIII.

Of the FIRE-STAFF or STICK.

The Fire-Staff may sometimes supply the want of an Artificial Fig. 187. 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 suitable Composition up to the Brim; and bore them to ½ of their Height with a proper Borer.
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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 a 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.

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**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 3 iij; of Sulphur 3 ij j; of Coal 3 j j; of Crude Antimony 3 ij; and of common Salt 3 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.
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 Constraction 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 Contruction 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-
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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 possession 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.

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 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 Shoulderrings 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 Cafe, 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. 191: 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 Cafe 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 flower the Inside of the Cafe 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 Cafe 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 Morteses 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 Morteses you must contrive to fix Paper Cakes 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 Fuizes or little Holes branching out from the Body of your great Tube to the Corn Powder beneath your Rockets.
SORT IV.

Fig. 192. I can hardly add any thing farther of this to what I have already said above; for this Cafe 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 glued, nailed, \\etc. upon the Convexity of the great Tube or Cafe, 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 Sitnilar 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
Book V. Of the Great Art of Artillery.

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 anything 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.

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.

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 Lift or Interstice between the Flutes or Channels, and the 6 others

P P P P
shall be left for the Channels betwixt the Lifts. 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 \( \frac{1}{2} \) for an Interpace or Lift, 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 Interpaces or Lifts, 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 \( \frac{1}{2} \) or \( \frac{3}{4} \) 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 \( \frac{1}{2} \) or \( \frac{3}{4} \) of your Flutes in Depth, and the Breadth of \( \frac{1}{2} \) only. These Chambers are designed to hold Corn Powder.

Reinforce these Mortars strongly with Paper Cages 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 Cage 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 Lifts or Interpaces, and bind the Middle of them with an Iron Plate fastened at each End upon the Face of the Interpaces: 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 Cage, which must be filled with Meal Powder, exactly upon which you must place the Touchholes 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 Cafes 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 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 lb; of Salt-petre 8 lb; of Coal 4 lb, and of the Filings of Iron or Hammer-slaw 2 lb.

II.
Take of Powder 24 lb; of Salt-petre 10 lb; of Sulphur 6 lb; of Coal 4 lb; of Colophane 2 lb; and of the Raspings or Saw-Dust of Wood 8 lb.

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 Cafes; 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 faith.

† 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 Propr-

† Vitruv. Lib. X. Cap. II.
Of the Great Art of Artillery. Book V.

ions 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 Quandrants, 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 Roundness (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 Philosophiae 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 fame 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
your Spiral more or less frequent) then from the Upper Extremity or Ver-
tex of the said Perpendicular, produce an Oblique Line or Hypotenuse
terminating in the other Extremity of the Base or given Right Line:
This done, cut out this Triangle in Paper; and by circumvolving or wrap-
ning the Base of it round the Perimeter of the Cylinder, the Hypotenuse
by its oblique Embrace will circumscribe a certain Limit upon the Con-
vexity of the Cylinder which will be your first Spiral; having then de-
scribed 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-An-
gled 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 Cafe of the aforementi-
oned Sort, the Hypotenuse will make a perfect Spiral upon the Con-
vexity 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 Ejecteurs as we said above.

C H A P. XI.

Of several Recreative Pyrotechnical Machines and Engines,
composed of Rockets, Crackers, Globes, Wheels, Buck-
lers, Clubs, Symetars, Swords, Poles, Staves, Tubes or
Cafes, and all such like Artificial Fires.

A L L that we have hitherto said of Artificial Recreative Fire-Works,
tends to this Chapter as to its Center: And all that we have hi-
therto 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 inwining into you a Knowledge of the se-
veral Essentails, and furnishing you proper Materials to build with. In
this Chapter I shall teach you the Assenblage of them, which is defined
to be, an ordering and disposing of the several Parts so that they may not
hinder and embara$ 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 par-
ticular Branches, of which I shall here make Choice of two without spe-
cifying the rest which the Architect ought to be perfect Matter of, and
which the Pyroblast ought not to be wholly ignorant in. The first then
shall be the Thematism (from the Greek Word συματισμoς) which signi-
ifies the Decorum and Gracefulness of any Pile; and is defined to be the
making the whole Apparatus of a Fabric to 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 af-
siduous Study and Diligence of the Engineer, in collecting all such In-
ventions and Contrivances as may be futable to the Time and Place,
where and when he exhibits his Work to the Public; and in accommo-
dating 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 Know-
ledge of why, and bow 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 Expen$es. And a-
bove all Things requires us to provide as much as we can towards our Safe-
$ty and the Preservation of Life; and that, not with regard to ourselves only,
but also with respect to those who might incur great Dangers through
our Miscondu$ and Imprudence. These are the two Pyrotechnical To-
pics which I propose to enlarge upon, and entertain you with in the Se-
quel.

Of the Thematism, Decorum, or Gracefulness which is to
be observed in the Ordering of our Recreative Pyrotechni-
cal Machines.

Both Ancients and Moderns have allotted four general Times or Oc-
casions for exhibiting of Artificial Fire-Works. The First: At the Con-
secrations, Inaugurations, or Coronations of Popes, Emperors, and Kings;
at the Receptions of great Princes and Generals; and at the Elections of
City Magiftrates.

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 Gregorius mentions to this Effect. † Theodorus upon the Decease of his Father was lifted up upon a Shield and acknowledged as Emperor; and Michael Psellos was admitted to the Empire with the same Ceremony. Julius Capitolinus faith: | During this, Caesar Gordianus was lifted 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; faith: 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 faith: † 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.

‡ Aur. Cal., Lib. X. Var. Epit. XXXI.

This
Of the Great Art of Artillery. Book V.

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 Armorial 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 Foremoit. This Device alludes to an ancient Custom established amongst the Poles, after the Death of Premislaua or Leocus 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 Leocus, 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 Cramer'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 Frederick 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
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Good and Evil. The Wheel then is a proper Emblem of Fortune; by which is meant Divine Providence; as we are taught by Esop, 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 changeable 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 Pyrobole 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. En.
‡ Ancilia, were a Sort of Iron 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 Pyrobolus 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 Obeliskal; and in short, the Naval or Rostral Crowns composed of the Beaks and Prows of Ships. But that our ingenious Pyrobolus 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 Rufinus and Thomas Dempterus have collected of this Matter from several Authors concerning the Roman Antiquities: First then Rufinus 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 inscrib'd 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 sailed a Wall, had a Mural Crown given to him; if he had formed some Castle, his Crown was futed 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 faced 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 naught to exceed that of all Crowns whether of Gold or of Silver.

Nor was Virtue rewarded in particular Persons only, but whole Cohorts andLegions were honoured with Presents and Marks of Distinction. Thus a great Part of the Spoils was divided among 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

+ Ruf. Lib. X. Cap. XXIX. ¶ Zon. Lib. II.
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 Triumphant 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 Garland, 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 Youth's richly drest: 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, 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 Carriage or Car, were carried the Crowns of Gold, with which he had been complimented by Embassadors from the Cities and Provinces, as was the usual Custom. Then came the Emperor himself in a sumptuous Car, magnificently habitated, and shining in a Triumphant Robe, crowned with Laurel, and holding forth a Branch of the same in his Hand. The Triumphant 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 Injulence to appear in the midst of them with his Triumphant 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. Dionyntus 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 seeming 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 Triumphant 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 Palsinus, (of which
which Plin. Lib. XXVIII. Cap. IV. speaks thus:—*The God Fafcinus 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. Zonaras also faith, 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 faith, 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 faith 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 Flaminus. 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 jingle 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 Triumphant Clamour, or chanting Poetry upon the Occasion, or breaking Jefts upon one another, or the Spectators. The numerous Crowd 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 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 Expense, 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 tua 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 Caesar 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 Pannels. 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 Caesar 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 Hermaphrodite Steeds; and the Insolent Triumph of Sufacus King of Aegypt, 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.
Of the Great Art of Artillery. Book V.

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 Maffes, 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 Lieutors or Heralds richly clad in fine Purple; and after them a Crow 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 Infirmity: In Allusion to which Juvenal has this Satirical Fling.

Illinc corniciones, hinc precedentia longi
Agminis officia, & nivos ad frana 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 flatter’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:

\[
\text{--- Piēsasque togas velamina summo}
\text{Ter confpecta Jovi.}
\]

*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 Maffy Gold or Silver, and sometimes of Iron; but most commonly of Ivory, as we may learn from *Ovid* in *Lib. de Ponto Eleg. IV.*

\[
\text{Oppida turritis cinguntur eburnea muris.}
\]

**In English:**

The Ivory Towns begirt with Towered Walls.

And *Claudian Lib. III.* *de Laudibus Stilich.*

\[
\text{Oßenarent suos prifico ß more labores,}
\text{Et gentes superent vulgo monstrare fubaétas.}
\text{Certarent utroque pares a cardine laurus,}
\text{Hae alemannorum spolis, australibus illa}
\text{Ditior exveuis, illic flavente Sicambri}
\text{Caesarie, nigris hinc Mauri crinibus irent:}
\text{Ipse albis veberetur equis, currumque secutus}
\text{Laurigerum fêsto fremuisset carmine miles:}
\text{Hi famuli traherent reges, bi faeša metallo}
\text{Oppida, vel montes captivaque flumina serent.}
\text{Hinc Libyci fraëtis iugerent cornibus amnes,}
\text{Inde catenato gemeret Germania Rheno.}
\]

**In English:**

If still the Custom was in Pomp to shew
The Victors Glory, and the conquer’d Foe;
The North and South wou’d equally combine,
To make his Valour and his Conduct shine.
Here, thou’d the Warlike German Spoils be shewn,
And there, the richer Trophies of a warmer Zone.
Here, the Sicambi 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 Praifes 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 thou'd grieve with broken Urn,
There Germany in her chain'd Rhine thou'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 imitat fraeda sub arundine Crines, &c.

The ingenious Pyrobolus 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 Gifts 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:

Ma Pietas me duxit amor deposcere sevam
Supplicia, & dextras juvat insertare catenas.

In English:

Thro' Love and Piety I met my Pain,
And gladly gave my Right Hand to the Chain.
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 vaśas 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.

Tessor majorum cineres tibi Roma colendos,
Sub quorum titulis Africa tonfa 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 triumphata 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 Scipio.

The ranomed 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
very properly introduced upon Popular Rejoicings on the Score of Warlike Achievements, 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 Æthera diræ
Et feffa gaudens vadit discordia palla,
Quam cum sanguineo sequitur Bellona flagello.

In English thus:

The Dīræ sowe 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 atra Formidinis ora,
Iraque Infidiaeque, 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 Pavor, Iraque crībæ,
Frema ministrat equis Pavor aliger, ac vigil omni
Fama sone, variis rœrum succinent tumultus,
Aute volat currur.

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
BOOK V. OF THE GREAT ART OF ARTILLERY.

Some have feigned that Fear drove the Chariot of this Warrior God. Claudian in Book I. in Ruffin.

Fer galeam Bellona mibi, nexusque rotarum, Tende Pavor, fraudet seferes Formido jugales.

In English thus:

My Helmet let Bellona bring; Terror my Tracest sit, And pannie Fear, do thou, the rapid Driver sit.

The same Author de Laudibus Stiliconis.

--- currum patris Bellona eruentum, Ditibus exuviiis tendentem ad sidera quercum Proecdit, hiatorque Metus, sum fratres Pavorc; Barbara ferratis, inmeant colla catenis Formido ingentem vibrat succineta 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 Sitter of Mars, and others, that she was his Wife; and a third Class of them, assure us, that she was both his Sitter and Wife. She was represented with her Hair disheveled, and spread over her Shoulders, with a Torch in her Hand, as appears by Silius Italicus, Book V. Pgm.

Ipso facem quasim, as flamem sanguine multo Sparja comam, medios 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 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:

\[ \text{Die mibi Roma, alis cur flat Victoria lapsis} \\
\text{Urbem ne valet defervisse suam.} \]

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 Conquests, or of snatching Palms and Laurels from his Enemies.

Nemesis was the Goddess of Vengeance, the Rewarder of Virtue, the Queen of Causes, the Sovereign Arbitres 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 suitably 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 styled by \( \text{\textit{Cicero}}, \) the Inventress of Wars.

\[ \text{\textit{Cic.} Lib. V. de Natur. Deor. Cap. XV.} \]
Book V. Of the Great Art of Artillery.

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 giving 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 Virtue 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 burdensome 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 harassed 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 Sovereign 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 with 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...
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 Triumphant 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 Darius was the First of the Romans who triumphed for a Sea-Victory. Valerius Maximus tells us; "† That whenever Darius 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 Clammer 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 Artift had raised an Artificial Rock in the middle of the Sea; which appeared inaccessible, for the Dangers at which seemed to surround it; and frightful, because of its Precipices:
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 enormous 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 Victim 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, cowing down with the Reins upon his Neck, and sowing directly upon the Monster, the Heroe ran him through and through with his Spear; and from the Wound there rushed out a prodigious Quantity 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 represented the Arms and Name of the subjugated Town in Fiery Characters; together with the Royal Name of the King, and whole Sentences of Triumph and Glorious Import; all which were seen scattered 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 Ethiopia, who for her Mother's Pride and Vanity in boasting that she surpassed the Nereids in Beauty and Comeliness, 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.

Andromedamonostris, fuerat dedicata marinis, Hac 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 Catholic
Of the Great Art of Artillery. Book V.

The Rock bore allusion to the Town of Rochelle itself, and suited 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 Herefy, 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 Fortresses, 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 Gravelines, 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 satisfy the entire Bulk of his Readers? Do we not see every Day New Additions and Improvements tack'd 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 fait of it, and whatever can be drawn from what I have here inferred, 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 Feftivals; 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 Orobius Lib. VI. Eutropius Lib. IX. Zonaras 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 Vull. Lib. VIII.) After him Pope Clement the VI, at the earnest Solicitation 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 Xyficus 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 Piaficius 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 freest Accounts relating to this Matter, you may be informed by those who return this Year from Rome; for the Ceremonial 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. Firft then Rofinus speaks thus. † The Time for celebrating the Games drawing near, Messengers were dispatch’d 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

† Ref. Lib. V. Cap. xxii.
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 sung 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 sung Paens to the Immortal Gods, recommending to them the Safety 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 Flambeaux, 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 shewing with Gold, together with 200 Beasts of Prey of several Sorts, finely adorned; Wagons full of Mimics and all kinds of Actors; Boxers, fighting Sham Battles; Fellows counterfeiting the Cyclops:
crops: In short, it was wonderful to see them, and nothing was to be heard on 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, Gonfalon, and Streamers, of the Colleges, Halls, Temples, and those of all the Legions. To these succeeded a vast Crowd of People, disguised like Goths, Sarmatia 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 Pyrobolists, 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 Infolencies 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 accenfis devotam currere tedis
In nemus, & Triviae lumina ferre Deæ.

Ovid also de FaSt.

Sape potens voci frontem redimi—orāt
Fāmina lucentes pōrtat ab urbe fæces.

† St. Auguft. de Civit. Dc, Lib. X. Cap. Xilek
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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. *Laelian 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 Creffet-Lights of Sulphur and Dirt, as may be gathered from *Juvenal Sat.* II. and Verf. 91.

*Talia, secretia coluerunt Orgia tada
Cecropian fuliti Baptae laffare Cotytoo.*

_Lucius Ann. Senec. also:_

_Tibi votivam matres Grae
Lampada jaclant._

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.* Verf. 412, and the same Author Book XII. Verf. 132. Claudian, Books II. and III. *Mart.* Book II. _de Nupt._ Ovid's *Epifle* II. from Phillis to Demopboon, &c.

To these three Festivals the Athenians added Lamps, which they vowed to _Panathenae, 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 *αμμας*.

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._

† *Laelian Firm.* Lib. I. Cap. XXI.

And
Of the Great Art of Artillery.

And Statius Book II. of his Thebais; towards the End of it.

Tuque Aëthca Ceres curfu cui fémper anhelo,
Veivam jaciti quaflamus lampada myste.

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 crater camella,
Lac niveum pates purpureamque fapam
Mosquare per ardentes stipulæ crepitantis aceros
Trajacias celeri furena membri 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 infinitely surpass the Ancients, not only in Artificial Inventions, but also in Piety and Religion; however, left 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-
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flow 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.) Tæde or Faces Jugales, Faces Legitimæ, Tæde Geniales &c.; that is, Nuptial Torches, Legitimate Torches, &c. Claudian sings thus, Book II. in Rufin.

— 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.

Seneca the Tragicomedian.

Et tu qui facibus legitimis ades
Nostrum disicutiens auspice destræ,

Ovid also Fastor. II. and elsewhere.

Conde tuas Hymeneæ faces, & ab ignibus atris
Auser, habent alias maesta sepulchra faces.

In English:

Go Hymen, stop the long-expecting Dames,
And hide thy Torches from the dismal Flames.
BOOK V. Of the Great Art of Artillery.

Thy Prefence 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 ratify 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 pinaca teda 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 Demppherus: 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 Pyrobolus will have a notable Foundation to build upon. But here, if he would follow the most general Rules that

† Fest. Lib. VI. ‡ Laft. 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 easly) 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 shal 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 administered 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.

Rofinus 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.

Spicataeque faces, sacrum ad nemorale Diane
Sistimus, & solito catuli velantur bonore,

† Rofin. Lib. II. Cap. VI.
BOOK V. Of the Great Art of Artillery.

Ipsaque per flores medio in discriminé lucis
Stravere armá jacris.

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 Chace 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 Scallop-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 signify that Love is contracted by Blandishment, Candor, and Sincerity; or that the Votaries of that Divinity are always outwardly Neat, Polite, and Gentle, 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 Voluptuounes divests us of our best Drest, 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 Praecept. Connub.) to admonith 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.
Of the Great Art of Artillery. Book V.

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 intemperate 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 signify 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,

\[
\begin{align*}
\text{Omnis habet hæc Voluptas,} \\
\text{Stimulis agit fruentes,} \\
\text{Apiumque par volantum,} \\
\text{Ubi grata mella fudit,} \\
\text{Fugit \& nimis tenaci} \\
\text{Figit ita corda morfa.}
\end{align*}
\]

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.

Philopratatus 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 signify 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 Thyrus, 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 Pyrotechnic 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 Drefs 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 Paffion, which for the generality runs into Extremes. Upon his Forehead he had this Device Αἰγίς & Ηώμοις, 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, Longē & Propō, or Far and Near; meaning thereby, that the Diftance of Place from the Object beloved, is unable to diunite 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 lay 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 Firft, a Profil of the Second, and the Third turned her full Face towards you. Seneca 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 Firft 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 fordid Views of Gain, or Expectation of a Return. They were pictured nak- ed, 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 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 Ἐγν. I. but we shall speak more at large of him in his proper Rank.

\[\begin{align*}
&\text{Hunc latum Tyriifque diem Trojaque profe\'dis} \\
&\text{Esse velis, no\'strofque hujus memini\'fque minores.} \\
&\text{Ad\'it letitiae Bacchus dator, & bona Juno.}
\end{align*}\]

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 Mien, and of a pleasaunt 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 Basins 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 Naiad, and the Story of Actaeon, 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 Nautical and Genethlian Fires, I shall defer, 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 surprise 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 referred 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 Nyssa, between the Nile and Phenicia, 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. Aniq. Cap. V.
membrane of Misfortunes and Miseries in those who are his hearty De-
voles. Hear Ovid.

Cura fugit, multo diluiturque mero,
Tunc venient risus, tunc pauper cornua sunti,
Tunc dolor & curae 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 Au{sonius has in a more particular Manner traced up his Genealo-
gy, his Appellations and Attributes, in Epigr. XXVI.

Ogygia me Bacchum vocat.
O{yrim Ægyptus putat.
Mysa Phanacca nominant.
Dionysos Indi exi{t{m{nt.
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 My{s} call me Phanaces.
The Indians say I'm Dionys'.
Th' Adonis of Arabia.
The Pan'thus of Lucania.
Me Rome, her Liber Pater claims.
To each a God, tho' call'd by different 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 Baccbe tener jucunda confitor uae.
Book V. Of the Great Art of Artillery.

In English:

But thou, O gentle Bacbus, Planter of the Grape.

Macrobius describes the Image of Bacbus 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 Cibus, 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 Albrec. 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 Bacche, the Bessarides, the Lenae, the Thyades, the Mimmolones, 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. IV.

\* Macrobi. Lib. I. Saturn.
Of the Great Art of Artillery. Book V.

--- Chromis & Mnasylus in antro,
Silenum pucri fomno videre jacentem;
Inflatum befterno oenas, ut semper, Iaccho.
Serta procul tantum capiti delapsa jacebant:
Et gravis attrita pendebat Cantbarus anfa.

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.  

It is of him that Ovid thus sings, Met. B. IV.

Quique senex ferula titubantes ebrius artus
Susintet, & pando non fortiter baret afello.

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, jurse, age, jurse pater.

In English:

Th' old Soker's drunk, from's Ass he's 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 Economy 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 other wise 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?
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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 suits 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 Carestes 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 Armories 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 caus'd 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 covered over with Parian Marble, on which are expressed the great Actions of Trajan, and particularly the Dacie War. There you may see Representations of Fortresses, Butworks, 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 Horstes to Water; others carrying Trophies, and marching as it were in Triumph; as also Corsets, Helmets, Shields, and Bucklers, Belts, Clarions, Daggers, Javelins, Swords, Quivers of

BooK V. Of the Great Art of Artillery.

Arrows, &c. On that Side, where the Inscription is wrought, there are winged Victories accompanied by two Eagles.

Prudentius speaking of Simmacbus, 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, sanctesque Duces in curribus altis;
Fabricios, Curios, binc Drujos 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, Druj 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 Feftoons (so called from the Latin Word Festivitas, which signifies Mirth and Pleasantness) in token of Joy. Now, Feftoons are certain Ornaments composed of an agreeable Assemblage of Leaves, Flowers, Blossoms and Fruits. But you must take Notice, that in Triumphal Works the Feftoons 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 Feftoons, interpersed with Leaves or Branches of Olive and Vine. These will have a most beautiful Effect in your Pyrotechnical Works.
Of the Great Art of Artillery. Book V.

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, Guitars, Violins, Bag-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, Gaff-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 interpersed 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, Praetexta, Trabea, Paludamentum, &c. all which are still visible in what Reliques we have of the ancient Magnificence, whether Buildings or Medals. The particular Fashions and Uses of the abovementioned Habits may be found in Nonius Marcellus, Fustus Lipsius, Rosinus, Dempflerus, 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.
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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 Fundae or Slings, the Fundibuli, Bows, Cross-Bows, Javelins, Lances, Spears, Parituflans, Pikes, Half-pikes, Axes, Pole-axes, Clubs, Swords; add to these, Shields, Bucklers, Targets, Corlets, Breast-plates, Cuirasses, Crefts, Gauntlets, 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 sur- prise 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 Iconography, 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.

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ii. It
Of the Great Art of Artillery. Book V.

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 future 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 Expense 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 forbid 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 Carcase 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 Edifices, 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 Representation 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 within. But as for grand and considerable Machines, you may perceive the Orthography and See-Fig. 204.ography 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,
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Faced, Columns, and Obelisks (provided they are not very large) upon the Trunks or Stumps of Trees, or upon great round, or many-fided Blocks of Timber: These may be ordered much after the same manner with the Cages 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 Cage 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 Cages of Composition, and other Artificial Works: Add to these the usual Embellishments, (viz.) Pilasters, Parastiles, 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 Parallelipipeds, Polyhedronic Prisms or Pyramids, and then cleath them with waxed or pinched Cloths, or coat them over with Pasteboard: These may be filled with one or several Sorts of Cages, Sky-Rockets ready fixed, and neatly disposed in the Interstices between the Cages, and against the Sides of the Pile or Machine itself.

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 clothed. 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 Cages of Composition, which must be previously shaped according to the Curvatures or Flexions of the Body, and well re-inforced or woudled to secure them from flying abroad, or splitting by the Violence of the Fire, before they have perfomned their due Effects; and it will be proper to fix them upon some firm Support, that they may be immovable; 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 Cage within the Body or Skin, as may be observed in the Statue of Fortune in Fig. 202. But there are Fig. 204 others, who dextrously fill the Arms, Legs, Thighs, Hands and Feet with Running Rockets, or Crackers, or Cages of Composition curiously disposed
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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 immovable, 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 strengthened 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 Assittance 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 flow 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 Canvas, 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 Paste-board Mask, and Shoos, 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 flow 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 not
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 within 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, Fig. 202, C and F.

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, Transoms, Planks and Boards; Capitals of Columns (if there be any) the Parastyle, the Lits, the Flutes, Cornices, Friezes, Architravés, Modillions, Dentils, Trygliphs, Drops, Metopes; in short, the Plinths, Pedestals, Apophyses, Baies, 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 Balons with their Pedestals, and the M-
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Method 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 must 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 disquiets 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 suitable Intervals, may depart, fly up, and perform the Effects natural to them, thereby to increase the Diversion, and avoid Scandal. Furthermore, 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 spokè 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
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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, Saltpeter, 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 Cans 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 thoroughly 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 ever 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 Juncures 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) let 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 Faces 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 Poitures, 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; and to which, that our Pyrotechnic Novice may gather sufficient Direction in this Matter from the Orthographic and Stenographic 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, profligate 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
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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 Chapter, 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 tie on Ends of Match to the Neck and Ears or Handles of your Pot, if it be made of Clay, Fig. 206, as you may observe in Fig. 206. Your Vessel being thus ordered, and
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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 Ramp-
part, or a Wall; or from the Battlements of any Fortresses into the Fosse 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 Di-
fances, 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 they 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 Flah, 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 wrap'd up in it. Sometimes in-
stead of Quick-Lime you may use the Ashes of Oak or Elm, pro-
duced they are well feared and reduced to an impalpable Meal.

M E T H O D II.

Sometimes they prepare Vessels either of Glass or Earth with long 
Necks, (the Hollow of which is about an Inch in Diameter,) and bear-
ing a near resemblance to the Matraffes, Retorts, and such like Vessels in 
use with Chymists: The Body or Belly of these is filled with Corn Pow-
der, 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.

M E T H O D 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 Pow-
der shall be interspersed with Crackers, either single, double, or far-
ther 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 o-Fig. 206. 
ther of these; whereof the First distinguished by A has Hand-Gren-
ado's, the Second by B, has Iron Crackers.

M E T H O D
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 Purpofe 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 lb; of Sulphur 4 lb; of Oil of Rosin 2 lb; of Saltpeter 1 lb; of Olibanum one lb; of Camphire 6 3/4; and of the best Brandy 14 3/4: 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, wherever it be thrown. Ufianus in the third Treatise of his Artillery, Chap. XX, gives us the following: Take of Gun-powder, Sulphur, Saltpeter, and Sal Armoniac, of each 2 3/4; of Camphire 2 3/4; 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 Pâte, 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 Intervals between these Balls with a Mixture of Corn and Meal Powder. This Composition is thus: Take Saltpeter and Gun-powder, of each 2 lb; of Sulphur 1 lb; of Colophone 3 3/4; of Camphire 3 3/4; of Sal-Armoniac 3 3/4. 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 outrageously; 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 ascend and inflame those Substances which are the least susceptible of Fire:
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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.

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That these Olla 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-Grenade'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.

C H A P. 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.
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Our Diadems and Garlands, I must own, will burn, and oftentimes prick those who handle them; but who knows not that Ropes are gathered amongst Thorns? And that all our most perfect Happiness, and most tranquil Contentment in this World, take Birth, in the midst of the most pungent Sorrows, and a thousand affecting 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 Emolumen upon a Soldier to lay 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 contems 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 lb; of Sulphur one lb; of Powder 2 lb; and of Powder of Glass 1 lb.

II.

Take of Saltpeter 3 lb; of Sulphur one lb; of Charcoal 1 lb; of Powder of Glass 3 lb.

III.

Take of Powder 2 lb; of Saltpeter 3 lb; of Colophine 1 lb; 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

Fig. 207 be remarked in Fig. 207 and 208.

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 Grenads, 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.

These Crowns and Garlands are applied to the very same Uises 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.

Fig. 210.

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 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 Diamentically 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 whole Representation you have in Fig. 211, it differs from those we have above-described: Hanszel 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 lb of Powder, one 3 of Sulphur, and 3 1b 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 reinforce it throughout with a Wounding 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 Bow, 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.
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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 infensibly 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 prefently to the Bottom of them, and unravel them at once; and thereupon their Hearts being dispensed 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, but theirs; 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 among their Inventions, and separate it from what is unuseful to us, and after having cleaned it, and scoured 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 ancient
cient Authors, that the Pyrotechnic Cylinder is a very antique Inven-
tion; 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) those they rounded
very exactly that they might be the more rollable, and being trundled down
Declivities, they ran over the Enemy and frightened 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 Cy-
linders 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. 312. The 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. 313. 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 com-
mon 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. 314. 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 clofly, 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 Fuze 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 Salluʃ; 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 Salluʃ, was no more to ours, than a Shadow is to a Substance. You have the Representation of this in Fig. 215, and by the Constru- Fig. 215. tion 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. "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, between 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 Pip A) by which means they will be immovably 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 ordered, shall be mounted upon two common Wheels, such as those of a Chariot with their Axle-Trees, which must exactly fit the Orifaces of the Cylinder, and be securely stuck into them: These Axles shall be also bored throughout to the Breadth of an Inch or thereabouts, which Borings must be filled with the usual Compositions for Fuzes. In fine, this furious Body (which for its admirable Constru- tion 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 perform 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
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 escaladed, 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 tie a strong Canvas 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 Fuzees, 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.
C H A P. 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 ‡ Dalmata called 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 fame Purpofe, || Having boldly passed the Fosse 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 further; 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 thofe, who would make any hurtful Attempt upon our Lives and Fortunes. We now prepare great Tuns, in the Center of which we fix a leffer Vessel or Cask full of Powder, or else a large Bomb; which we surround with Stones, Pebbles, Iron Bolts, &c. the Interfices 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 Ram-parts 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 lefs can I make you believe it, except you have ever hap-

† Dio. Cafl. Lib. LVII. ‡ Now called Scythonians. || Amm. Lib. XX.

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pened to be in some fort 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 affUAGE 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 Martyrizing 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 Ruffel, 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 Caesar in Lib. II. of the Civil Wars; who speaking of the Siege of Marfelles, says, “That finding the Besieged very obstinate in defending themselves, a Myclus 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 completed 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 Gallery; 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 Purpose 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 upon the Gallery, but they immediately rolled off, and were easily removed out of the way of doing Harm, by long Prongs or Pich-forks. In the mean time the Soldiers that were under the Covert of the Gallery, loofened and pulled out the lowermost Stones of the Enemy’s Tower; and having taken out a good Parcel of them, and under-mined it, 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 Artifices 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, Plaiks, 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 inclofe 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. Fig. 219, 220 and 221. But the last of them shews you two Barrels mount-ed 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-ed
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ed upon Iron Axles, and that the Wheels have Iron Straiks and Spokes 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 shows 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 Flambeaux or Torches.

By Torches we understand nothing more than certain Brands of Artificial Fire, which are thrown at Diftances 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 Caesar 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 altruar each other (alternately) like a Funeral Pile, which being pretty big, they might from thence repel the Assaultants with Spears and Stones. Caesar 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 Faggins 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 Faggins 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, Caesar was astonished at it, and ordered his Army to advance up to it, and infect 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.

† The Latin Word is Suedes, which were properly a kind of Staves. Silius
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Silius mentions these Torches in Pugn. Canon.

Ullum nec desit teli genus, bi Sude pugnant,
Hi Pinu flagrante cient; bi pondere Pili.

In English:

They deal all mislive Arms, fatal to Life;
Thefe with the flaming Torch provoke the Strife,
Those with the Javelin's Weight, &c.—

Lucan also in his Pharsalia.

——— inde Sagitta
Inde Faces, & Saxa volant.

In English:

Thence Stones, thence Brands and Arrows fly.

Virgil also faith somewhere.

‘Jamque faces & saxa volant, furor arma ministrat.

In English:

And Brands and Stones in ratling Vollies fly;
And all the Ruffic Arms that Fury can supply.

Dryden.

Lipsius also in Lib. V. of his Poliorceticwn, 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 Ufe in their Houfes; 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 Piafeciws will furnifh us with an Example of a frether Date; for speaking of the Siege of Wielholuki (a Town in Muscovy) when it was invested and taken by Stephen King of Poland, he tells us; “That the aforefaid Town being surounded by an Encient comofed of vaft Bodies of Timber, upon which Account, and for other Reafons, it was found to be Proof againft 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 extinguifhied by the Dil-igence of the Moscovites besieged; but that fame Evening they conveyed Brands or Torches made of Sulphur, to the other Side of the Town, which lying latent for ferveral Hours, it was thought they were extinguifhied by the Dampness of the Ground: But a high Wind arising towards Midnight, they flamed out afresh, and in a very litt-le time the Conflagration became general, and the whole Place was laid in Afhes; 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 Colophene 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 fluid, throw into them some Old Linnen well washed and dried, or else Tow; but whichsoever 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 Wire; 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. Feius is to the full as much mistaken; says he: Not only small Mallets are called Malleoli; but these 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: the 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 Rofin, 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, or Point, is armed with an Iron several times doubled, and made like a Woman's Diffaff: 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 fast 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 Malleoli almost to the same Purpose, namely, * The Malleoli are like Arrows, and because they carry Fire with them, they burn whatever they stick in. *æve: a very Ancient Author calls them simply Fire-Arrows or Darts, as may be learned from Ifaac Casaubon’s Translation of him into Latin, where he renders them Sagitta ignifera; Ignifera 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 biggest & 2+: of a Goose’s or Swan’s Egg, (which may be either longish or perfectely Round, as we formerly specified with Relation to Fire-Balls) and fill it with a Composition made of 4 lb of purified Saltpeter; 1 lb of Sulphur; 1 lb of Meal Powder; 1 lb of Campbire; and 1 lb of Colophone. Or else: take 2 lb of Saltpeter; 2 lb of Powder; 1 lb of Sulphur; 1 lb of Colophone. Or this Third Composition which is as good as either of the Two former (viz.) 8 lb of Saltpeter; 6 lb of Powder and 4 lb 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 immovable, 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.

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.
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Of the two other Darts; that which you see in Fig. 223 has a Concave Spherical Head, which usually incloses a Hand-Grenade 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 Pyromaniac will find more of them in Brebelsius, Part II. Chap. III. In Uefanus, Treatise III. Chap. XXXIII. In Hanzelet, Page 162. In Jerome Ruffel, 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 awkward 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 Uefanus (in Treat. III. of his Artillery, Chap. XXXIII.) that the Spaniards found very successful Service from them at the Sieges of Xprel 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 Cramer relates; who speaking of the mighty Exploits of the Poles before the Town of Chezine, 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 Cover 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 Com-
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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 Phalarica, and were usuallly 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 fir out, they the more outrageously defended themselves with Malleoli and Phalarica, which they fhot flaming from the Ballista. We shall speak of the second Way of dismiffing 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 describ'd 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 Roffin, Bitumen, and Tow steeped in Oil which is called Fiery; and being fhot from the Ballista, 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. Livius 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.

Armed clauros, & portis arciuit boflem,
Librari multa conjucta Phalarica dextra,
Horrendum vigu robur, celsifique nivoce
Pyrenes trabs lecita jugis cui plurima Cuppis,
Vix muris toleranda lues, fed cetera pingui,
Uniska pice, atque atro circumlita sulphure sumat.
Fulminis bac ritu summis è manibus arcis
Incita fulgatum tremula fecta aer a flamma.

In English thus:

With a Phalarica, whirl'd by many Hands,
The brave Besieg'd rep'ld 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' Pyrenean Hills. This arm'd around,
With bearded Spikes of Steel, would scarce have found
Obstruction from firm Walls. The rest befear'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.

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 Aeneid.

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 withheld;
Nor Coat of double Male with Scales of Gold.
Down funk the Monster-Bulk and press'd the Ground,
His Arms, and clattering Shield on the vast Body found.

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 Haftæ Ardentes, or Fire-Lances or Pikes; which Appellation of them we retain, by the common Consent of all Pyrotechnicians and Pyrobolistl: For the Italians call them Dardi de Fuoco; the French, des Lances & Piques a Feu; the Germans, Fewer Picken; the Flemings, Yper-Spissen; and in short, we (the Poles) call them Ogniska Włoczenie or Kopie.
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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 Fig. 229, 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 Phalaricides of the Ancients: Or on the contrary it is in Respect of this, that the Phalaricides 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 Baliste and Catapultae, as appears by the Testimony of the Authors above-quoted.

But on the other hand we have Fires that are more Artificial than the Phalaricides, 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 Mischiefe as several Musqueteers. Furthermore, 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 give you only one Sort of the Military Fire-Cafe, which you have in Fig. 226; and which in point of Form is exactly like the Fig. 226, Recreative Cafe in Fig. 195. And for my part, I cannot see why we should not apply our Recreative Cafes 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.

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 anywhere 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 Expense; to Knowledge without Discipline; to the Triumphant without War; to Perpetuity without Moments; be ascribed all Praise, Might, Majesty, and Dominion, both now and for evermore.

FINIS.