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Gunpowder and ammunition.

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1904

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GUNPOWDER AND AMMUNITION

THEIR ORIGIN AND PROGRESS

BY

LIEUT.-COLONEL HENRY W. L. HIME
(LATE) ROYAL ARTILLERY

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BOOKS OFTEN QUOTED

THE following works are frequently quoted, and are only designated by the author's name. Thus, "Elliot," ii. 75, means Sir H. M. Elliot's "Hist. of India, as told, &c. &c.," vol. ii. p. 75.

BACON, ROGER, *Opera quædam hactenus inedita*, ed. by Professor Brewer; Rolls Series, 1859.

BERTHELOT, M. P. E., *La Chimie au Moyen Age*, Paris, 1893.

BRACKENBURY, Lieut.-General Sir H., G.C.B., "Ancient Cannon in Europe," in vols. iv. and v. of *Proceed. Roy. Artillery Institution*, Woolwich, 1865–6.

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JÄHNS, Oberst-Lieut. M., *Handbuch einer Geschichte des Kriegswesens*, Leipsig, 1880.

NAPOLEON III., *Études sur le Passé et l'Avenir de l'Artillerie*, Paris, 1846–71.

NYE, Master-Gunner N., "Art of Gunnery," to which is added a "Treatise on Artificial Fireworks" (separately paginated), London, 1647.

REINAUD (Professor) et FAVÉ (Capitaine), *Du Feu Grégeois*, &c., Paris, 1845.

ROMOCKI, S. J. VON, *Geschichte der Explosivstoffe*, Hanover, 1895.

WHITEHORNE, P., "Certain Waies for the ordering of Souldiers in Battelray," London, 1560.

against the Bulsar pirates in 1482 (p. 116). These "Franks," we learn from the *Wu-pei-che*, "were of iron, 5 or 6 *ch'ih* (6 or 7 ft.) long. . . . Five small barrels (chambers) were used, which were placed (successively) inside the body of the piece from which they were fired off."[1]

(*q*) The Chinese guns manufactured in 1618 were cast under the superintendence of the Jesuits at Peking.[2]

The general conclusion to be drawn from the foregoing inquiry is virtually Gibbon's, which may be expressed in somewhat firmer language than he has used, since we possess many facts which were unknown to him. It is highly probable that the invention of gunpowder was carried from the West to China, by land or water, at the end of the fourteenth or the beginning of the fifteenth century, and "was falsely adopted as an old national discovery before the arrival of the Portuguese and the Jesuits in the sixteenth."[3]

[1] Mayers, p. 96.

[2] Professor R. K. Douglas, "China" ("Story of the Nations" series), p. 74.

[3] Decline and Fall," &c., vii. 11 *n* (Bury's ed.).

CHAPTER VIII

FRIAR BACON

ROGER BACON was born at Ilchester, in Somersetshire, in 1214, and died about 1294. If the dedication be authentic, his *Epistola de Secretis Operibus Artis et Naturæ et de Nullitate Magiæ*, the work with which we are chiefly concerned here, was written before 1249.[1]

Bacon attacks Magic in this book on the ground that science and art can exhibit far greater wonders than the alleged wonders of the Black Art, and to prove his point he enumerates, in the first eight chapters, a number of wonders which (he believed) art could produce and magic could not. Everything is sufficiently clear until we reach the ninth, tenth, and eleventh chapters, and they are unintelligible as they stand. Now, it is past belief that a man of commanding genius should have deliberately stooped to write page after page of nonsense. The three chapters, therefore, must have *some* meaning, hidden from us though it be.[2]

It is unquestionable that Bacon believed he

[1] "Roger Bacon," in *Ency. Brit.*, by Professor Adamson.

[2] "Quand le sens littéral est absurde, incohérent ou obscur . . . on doit présumer un sens détourné."—Langlois et Seignobos, *Introd. aux Études Historiques*, p. 127.

possessed secrets of vast importance. At the close of Chapter VIII. he tells us by way of warning that he may resort (in the following chapters) to certain cryptic methods, "on account of the magnitude of his secrets" (*propter secretorum magnitudinem*); and, fearing that ordinary cryptic methods might be too transparent, he wraps up his secrets in an anagram in Chapter XI.

If Bacon were in possession of such secrets, why, it may be asked, did he not publish them openly? The reason was, as he explains repeatedly and at length, that he firmly believed scientific knowledge to be hurtful to the people. He protests in his works again and again against the diffusion of scientific information. "The crowd," he says, "is unable to digest scientific facts, which it scorns and misuses to its own detriment and that of the wise. Let not pearls, then, be thrown to swine."[1] Elsewhere he says: "The mob scoff at philosophers and despise scientific truth. If by chance they lay hold upon some great principle, they are sure to misinterpret and misapply it, so that what would have been gain to every one causes loss to all."[2] "It is madness," he goes on to say, "to commit a

[1] "Vulgus (arcana sapientiæ) capere non potest, sed deridet et (abutitur) in sui et sapientum dispendium et gravamen. Quia non sunt margaritæ sapientiæ spargendæ inter porcos."—*Compendium Studii*, p. 416.

[2] "Vulgus deridet sapientes, et negligit secreta sapientiæ, et nescit uti rebus dignissimis; atque si aliquid magnificum in ejus notitiam cadat a fortuna, illud pervertit et eo abutitur in damnum multiplex personarum et communitatis."—*De Secretis*, cap. viii.

secret to writing, unless it be so done as to be unintelligible to the ignorant, and only just intelligible to the best educated";[1] and so much in earnest was he upon this point that he enumerates seven methods of baffling public curiosity. A secret may be concealed by making use of:—

(1) Symbols and incantations (*characteres et carmina*);
(2) Enigmatic and figurative words;
(3) Consonants only, without vowels;
(4) Letters from different alphabets;
(5) Specially devised letters;
(6) Prearranged geometric figures;
(7) Shorthand (*ars notatoria*).

These are among the means of veiling secrets, he tells us, and "ill will it betide him who reveals them."[2]

Bacon was not singular in holding the doctrine of secrecy in matters of science, nor was it peculiar to the age he lived in: it arose ages before his birth, and was held for ages after his death. To any objections that might have been raised against the doctrine, philosophers would probably have replied with Subtle and Mammon:—

> ". . . was not all the knowledge
> Of the Egyptians writ in mystic symbols?
> Speak not the Scriptures oft in parables?

[1] "Insanus est qui aliquid secretum scribit nisi ut a vulgo celetur, et ut vix a studiosissimis et sapientibus possit intilligi."—Ib.

[2] "Multa mala sequuntur eum qui revelat secreta."—*De Secretis*, cap. viii.

Are not the choicest fables of the poets,
That were the fountains and first springs of wisdom,
Wrapp'd in perpetual allegories?
. . . . . .
. . . Sisyphus was damned
To roll the ceaseless stone, only because
He would have made Ours common."[1]

A man who boldly, even fiercely, avowed such opinions as Bacon's, was bound in consistency to employ some cryptic method in recording his own secrets; and when we closely examine the course Bacon actually followed, we find that his practice was rigidly in accordance with his theory—in fact, too rigidly. Those steeped in the Cabbala of Alchemy in his own age may have grasped his meaning, but to those who came afterwards it was obscure, if not hidden. Even to the early copyists of his MSS. it was unintelligible. In one of the MSS. consulted by Professor Brewer, the scribe has written on the margin of Chap. IX. of the *De Secretis*:—*Hæc sunt ænigmata;* "these things are enigmas," and enigmas they have remained for seven centuries.

The presence of two anagrams in Chap. XI. is sufficient of itself to arouse a suspicion that some cryptic method (of a different kind) has been employed in Chaps. IX. and X., and this suspicion is strengthened by their whole manner and diction. Their style is involved, and their meaning (as they stand) unintelligible. Bacon passes from one subject to another in bewildering haste; from the

[1] Jonson's "Alchemist," Act II.

unfinished description of one process to instructions about a second, which he leaves half told in order to plunge into a third. Among directions of *seemingly* primitive simplicity he interpolates such phrases as "catch my meaning if you can" (*intellige si potes*); "you will see whether I am speaking riddles or the plain truth" (*videas utrum loquor ænigmata aut secundum veritatem*); and he warns us that the purport of Chap. IX. may wholly escape us, unless we distinguish the (real from the apparent) meaning of his statements (*in hoc capitulo decipieris, nisi dictionum significata distinguas*). These special peculiarities of Chaps. IX. and X. can be only explained by the use of some cryptic method, to which Bacon points plainly in Chap. VIII. He there names two cryptographers, Ethicus and Artephius, in connection with the seven cryptic methods already given, and he broadly hints that he may make use of some of these methods (*forsan, propter secretorum magnitudinem, aliquibus his utar modis*). It is needless to pursue the matter further: Chaps. IX. and X. are not, as they appear to be, nonsense, but the cryptic exposition of some secret which Bacon believed to be of great value.

Few of the difficulties we experience in investigating the meaning of these three chapters were felt by the correspondent to whom the Friar addressed them as letters. He and Bacon had long been in communication with each other, and as both knew the substance which formed the *real* subject of these letters, Bacon was at liberty to call it chalk

or cheese or what he willed. They appear to have had some system of numerical signs, the meaning of which is lost to us. The tenth chapter begins with a reference to a letter received by Bacon from his correspondent in the year 602 A.H., and as the date is given in words, not figures, it can hardly have been mistaken by the scribes. Now the year 602 A.H. began on 18th Aug., 1205 A.D., nine years before Bacon was born. The number 602, therefore, is either a blind, or a conventional sign or key. The same may be said of the number 630 in the first line of Chap. XI., and of the totally unnecessary 30 which occurs just before the anagram in the same chapter—"(*sit*) pondus totum 30," *i.e.* let the total weight be 30. No one can have ever wanted to know the total weight of the mixture in question: every one wanted to know the proportions of the ingredients. Our ignorance of these signs creates difficulties for us which did not exist for the initiated in Bacon's time.

As will be shown hereafter, Bacon has occasionally availed himself in Chaps. IX., X., and XI. of Nos. 2 and 4 of the cryptic methods he has given us; but these methods apply only to words and phrases, and the wily Franciscan did not think it necessary to allude to the more general method by which he set forth so much of his statement as is contained in Chaps. IX. and X. We cannot discuss cryptograms here: suffice it to say that some of the early methods were too tedious and some too complicated to be employed throughout the whole length

of Chaps. IX. and X. The method he appears to have adopted (as the result will show) was that known long afterwards as the "Argyle cipher," of which the following letter from Thackeray's "Esmond" is an example. The real contents of this letter are the phrases within brackets:—

"[*The King will take*] medicine on Thursday. His Majesty is better than he hath been of late, though incommoded by indigestion from his too great appetite. Madame Maintenon continues well. They have performed a play of Mons. Racine at St. Cyr . . . [*The Viscount Castlewood's passports*] were refused to him, 'twas said; his lordship being sued by a goldsmith for *Vaisselle plate* and a pearl necklace supplied to Mademoiselle Meruel of the French Comedy. 'Tis a pity such news should get abroad [*and travel to England*] about our young nobility here. Mademoiselle Meruel has been sent to Fort l'Evesque; they say she ordered not only plate, but furniture, and a carriage and horses [*under that lord's name*], of which extravagance his unfortunate Viscountess knows nothing.

"[*His Majesty will be*] eighty-two years of age on his next birthday. . . . All here admired my Lord Viscount's portrait, and said it was a masterpiece of Rigaud. Have you seen it? It is [*at the Lady Castlewood's house in Kensington Square*]. I think no English painter could produce such a piece.

"Our poor friend the Abbé hath been to the Conciergerie [*where his friends may visit him.*

They are to ask for] a remission of his sentence soon.

"[*The Lord Castlewood*] has had the affair of the plate made up and departs for England.

"Is not this a dull letter? . . ."—Bk. III. Chap. 8.

This letter shows very clearly that the Argyle steganogram is one which it is almost impossible to solve without the key, unless the matter to which it relates is known beforehand[1]—a difficulty to which Bacon's correspondent was not exposed, for he knew well what the subject of Bacon's communication would be. Here, then, we should have found ourselves left in utter darkness were it not for a ray of light afforded by Chap. XI. There we are told that *something*, in connection with saltpetre and sulphur, produces an explosion,[2] and we know that this *something* is charcoal. Since Chap. XI. is concerned with the composition and effects of this mixture, what more probable than that Chaps. IX. and X. should deal with its ingredients separately—or at least with saltpetre and charcoal, for sulphur was so simple and common a drug that Bacon was not likely to dwell upon it? Now, towards the end of Chap. X. Bacon speaks without disguise of charcoal under the name of the wood from which it is

[1] "Cipher" in Rees' "Cyclopædia" and Klüber's *Kryptographik Lehrbuch*, Tübingen, 1809. In a note to these chapters in the *Theatricum Chemicum*, Zetzner says: "Hic tamen jacta esse Steganographiæ fundamenta certissimum est."

[2] "Tonitruum et coriscationem."

made;[1] and mentions the two trees, hazel and willow, which give the best. He significantly adds that when charcoal is added to proper proportions of certain other substances, something noteworthy happens (*si vero partes virgulti coryli aut salicis multarum justâ rerum serie apte ordinaveris, unionem naturalem servabunt: et hoc non tradas oblivioni, quia valet ad multa*). Since, then, charcoal is one of the subjects of these two chapters, it becomes all the more probable that saltpetre forms another. Bacon was writing but a few years after its discovery, and nothing could be more natural than that the great alchemist should bestow his attention upon the preparation of the new salt. This hypothesis explains simply and completely the most remarkable feature of Chaps. IX. and X.—the series of common and well-known alchemical terms and phrases, referring undoubtedly to the preparation of either saltpetre or gold, which are scattered and hidden among incoherent maunderings about chalk and cheese, philosophic eggs and Tagus sand, Adam's bones and aperient medicine. But how could the preparation of gold lead up to the recipe for an explosive with which Chap. XI. ends? There is no connection whatever between gold and gunpowder, while the connection between saltpetre and gunpowder is of the closest possible kind. Before giving a recipe for gunpowder it was absolutely necessary for Bacon to describe the method of refining the lately discovered saltpetre, without which his

[1] Æneas Tacticus adopts the same mode of expression, Table II.

recipe would have been worthless; and he took advantage of the close similarity between the alchemical preparation of gold and the refining of saltpetre to conceal the real import of his tract. By the title of the last three chapters—"On the Method of Making the Philosopher's Stone"—and by constantly harping on gold, he endeavoured to distract and deceive his ordinary readers, leading them to believe that he was writing about gold when he was really treating on saltpetre.

The unnamed substance saltpetre, then, is the principal subject of Chaps. IX. and X., and our course is clear. We must treat these chapters as we should treat Col. Esmond's letter were the brackets omitted[1]—we must make shift to insert them. We must bracket together the phrases and sentences relating to the real subject of these chapters, the familiar alchemical expressions relating to saltpetre. On doing so we shall find a connected and rational method of refining the salt.

In the following reproduction of Chaps. IX. and X. I have used the Esmond brackets, but I have not thought it necessary to reprint *all* the padding which connects them. All omissions, however, are shown by dots. No word of the bracketed phrases has been changed, altered, added, or suppressed, nor has the order of the words been altered. Nothing has been done but to indicate by brackets the misleading interpolations.

[1] That is, supposing we knew the subject of his letter, or had evidence which made it probable that it was so and so.

Cap. IX.

De modo faciendi ovum philosophorum.

Dico igitur tibi quod volo ordinari quæ superius narravi exponere, et ideo volo ovum philosophorum et partes philosophici ovi investigare, nam hoc est initium ad alia. [*Calcem*[1] *igitur diligenter*] aquis alkali et aliis aquis acutis [*purifica*], et variis contritionibus cum salibus confrica[2] et pluribus assationibus concrema, [*ut fiat terra pura penitus liberata ab aliis elementis*[3]], quam tibi pro meæ longitudinis statura dignam duco. Intellige si potes, quia proculdubio erit compostum ex elementis, et ideo est pars lapidis qui non est lapis,[4] et est in quolibet

[1] To lull suspicion he calls natural saltpetre chalk, a *verbum figurativum*. Other MSS. read "sal."

[2] "Tere ipsum fortiter cum aqua salis communis. . . . Ablue in aceto acerrimo." The section "Nitri Separatio" of "Aristoteles, de Perfecto Magisterio," in the *Theatrum Chemicum*, ed. by Zetzner; a collection of alchemical tracts of the Middle Ages, iii. 68.

[3] Almost literally translated by Whitehorne: "clarified and from earthe and grosse matter diligently purged." See A, p. 21.

[4] *i.e.* the lapis Assius = saltpetre. We have here unmistakably a *verbum ænigmaticum*. The efflorescence of the stone of Assos, which was unknown to the crowd, was of course "not a stone," although called so. The philosopher's stone, which was well known by name to the crowd, was likewise "not a stone," although called so:—

> ". . . 'tis a stone
> And not a stone; a spirit, a soul, and a body."
> —Jonson's "Alchemist."

Bacon avails himself of the ambiguity of the phrase, "stone which is not a stone," to support the delusion created by the title of the chapter, and confirm the unwary in the belief that the philosopher's stone is under discussion, instead of saltpetre.

homine et in quolibet loco hominis. . . . Deinde oleum ad modum crocei casei et viscosi accipias,[1] primo ictu insecabile, cujus tota virtus ignea dividatur et separetur per distillationem; [*dissolvatur*[2] *autem in aqua*] acuta temporatæ acuitatis [*cum igne levi*,[3] *ut decoquatur quatenus separetur pinguedo sua*[4]], sicut pinguedo in carnibus. . . . Melius est tamen ut decoquatur in aquis temporatis in acuitate [*donec purgatur et dealbetur*]. Aqua vero salutaris exaltatio fit ex igne secco vel humido; et [*iteretur distillatio*] ut effectum bonitatis recipiat sufficienter [*donec rectificetur: rectificationis novissima signa sunt candor et crystallina serenitas*[5]]; et cum cætera[6] nigrescunt ab igne hoc albescit, mundatur, serenitate nitescit et splendore mirabili. [*Ex hac aqua*] et terra sua argentum vivum generatur, quod est sicut argentum vivum in mineralibus, et quando incandidit hoc modo [*materia congelatur. Lapis vero Aristotelis, qui non est lapis, ponitur in pyramide in loco calido*[7]].

[1] He passes suddenly from chalk to cheese—yellow cheese, laughing openly in his reader's face.

[2] *i.e.* the cleansed natural saltpetre.

[3] "Put the jar on a gentle fire."—Hassan, A, p. 24.

[4] "The mother liquid is boiled until the scum ceases to rise."—Waltham Abbey process, C, p. 19.

[5] "Clear and fair and of an azure colour."—Whitehorne, F, p. 21.

[6] *i.e.* the scum and impurities.

[7] *i.e.* "to drie throughly."—Whitehorne, I, p. 22.

Cap. X.

De eodem, sed alio modo.[1]

Transactis annis Arabum sexcentis et duobus, rogasti me de quibusdam secretis. [*Accipe igitur lapidem*[2] *et calcina ipsum*] assatione leni et contritione forti sive cum rebus acutis. [*Sed in fine parum commisce de aqua dulci; et medicinam laxativam*[3] *compone de*] septem rebus . . . vel de quot vis; sed quiescit animus meus in [*duabus rebus quarum proportio melior est in sesquialtera proportione*[4]] vel circiter, sicut te potest docere experientia. [*Resolve*[5]] tamen aurum[6] [*ad ignem et mollius calefac*]. Sed si mihi credas, accipias unam

[1] This repetition corresponds with Whitehorne's second process; beginning at F', p. 22.

[2] *i.e.* the crystals just obtained.

[3] A powder to purge, or to purify and clarify. "Prenez de la chaulx vive et de l'eau de pluye . . . et les brouillez bien ensemble, et puis le laissez reposer . . . et se fera forte lexive . . . Prenez de la lexive dessus dicte, et mettez vostre salpetre dedans," &c. "Livre de Canonnerie," &c., which although not published until 1561, appears to belong to the end of the fifteenth century.—In Reinaud and Favé, pp. 146–7.

[4] Bacon does not name the two substances he alludes to, but Whitehorne names two and prescribes the same proportions: "Two parts of unslacked lime and three of oke asshes."—See A, p. 21. Did Whitehorne have access to Bacon's MSS.?

[5] Treating ostensibly on gold, Bacon is obliged to use *resolve* for *dissolve*.

[6] The alchemical preparation of gold had much in common with the refining of saltpetre. In the "Nitri Preparatio" of Bernard's and Penoti's *Theatrum Chemicum*, iii. 78, we read: "Fac postmodum de eo per omnia ut dicam in preparatione auri, id est, destilla per alambicum et congela," &c.

rem, hoc est secretum secretorum, et naturæ potens miraculum. [*Mixto*[1] *igitur ex*] duobus, aut ex pluribus, aut [*Phœnice*[2]], quod est animal singulare, [*adjunge, et incorpora per fortem motum; cui si liquor calidus adhibeatur,*[3] *habebis propositum ultimum*[4]]. Sed postea cœlestis natura debilitatur si aquam infundis ter vel quater. Divide igitur, debile a forti in vasis diversis,[5] si mihi credas. [*Evacuato*[6] *igitur quod bonum est.*] Iterum adhibe pulverem, et aquam quæ remansit diligentur exprime, nam pro certo partes pulveris deducet non incorporatas. Et ideo illam aquam per se collige, quia pulvis exsiccatus ab ea habet incorporari medicinæ laxitivæ . . . [*Regyra cum pistillo,*[7] *et congrega materiam ut potes, et aquam sepera paulatim*] et redibit at statum. Quam aquam exsiccabis, nam continet pulverem[8] et aquam medicinæ, quæ sunt incorporanda sicut pulvis principalis.

[1] *i.e.* to the laxative.

[2] A *verbum ænigmaticum.* The Phœnix is a singular animal, as Bacon justly observes, inasmuch as it springs from its own *ashes.* Its name, therefore, may be figuratively used with perfect propriety to denote *animal charcoal,* an efficacious agent in clarifying solutions of impure saltpetre.—Bloxam's "Chemistry," 8th ed., p. 488.

[3] Bacon appears to have poured the hot solution upon the laxative, precisely as Clarke directs in his "Natural History of Nitre," London, 1670, p. 42: "Pour the hot liquid on ashes . . . 'tis no matter how soon you let it run off the ashes again."

[4] *i.e.* the removal of the insoluble impurities.

[5] "Then pour it into the other jar."—Hassan, A, p. 24.

[6] *i.e.* into a crystallising jar.

[7] "The solution is kept in constant agitation by poles while cooling."—Waltham Abbey Regs., H, p. 20.

[8] "The mother liquid, from which the saltpetre flour has been deposited, is boiled down and crystallised."—Bloxam's "Chemistry," 8th ed., p. 488.

The phrases within brackets, which constitute the recipe, will be found collected together and translated in their proper place in Chap. II.

It would be presumptuous to suggest that the foregoing solution of Bacon's Argyle steganogram is free from error; but I may express a hope that the errors are few and inconsiderable—a hope founded upon the completeness of the method disclosed. Whatever errors may be found, there can at least be little doubt that the occult meaning of the two chapters is the refining of saltpetre. One sentence, two sentences, or even more, might be selected from the description of almost any long chemical process which would apply with equal propriety to some other process; but it is incredible that a long, varied, and connected process, such as the refining of saltpetre, could be extracted by any method from documents professedly devoted to the philosopher's stone, unless this process had been designedly inserted there, piecemeal or whole, by the author himself. For the figurative interpretation given of two or three words and phrases, we have Bacon's own warrant. He threatened to employ *verba ænigmatica* and *verba figurativa,* and he has been taken at his word; with the result that a rational chemical process has been extracted from what was previously unintelligible.

Having said all he had to say about the ingredients, Bacon proceeds to deal with their mixture in Chap. XI., in which he employs a cryptic method without disguise:—

Cap. XI.

De eodem, tamen alio modo.

Annis Arabum 630 transactis, petitioni tuæ respondeo in hunc modum . . . Item pondus totum 30. Sed tamen salis petræ[1] LURU VOPO VIR CAN UTRIET sulphuris; et sic facies tonitruum et coriscationem, si scias artificium. Videas tamen utrum loquor œnigmatate aut secundum veritatem.

Omitting the anagram, the translation is:—"In this 630th year of the Higira I comply with your request as follows. . . . Let the total weight (of the ingredients) be 30. However, of saltpetre . . . of sulphur; and with such a mixture you will produce a bright flash and a thundering noise, if you know 'the trick.' You may find (by actual experiment) whether I am writing riddles to you or the plain truth."

The mention of the flash and the noise indicates at once that we have here to do with an explosive. But saltpetre and sulphur when mixed together do not form an explosive. We may feel sure, therefore, that the name of the one substance necessary to convert the incendiary mixture of saltpetre and sulphur into an explosive, namely charcoal, is included under some form in the anagram—either as *carbo*, or the

[1] *Salis petræ* is the reading of Zetzner's *Theatrum Chemicum*, 1613, v. 962, which is adopted by Reinaud and Favé, p. 123; of Manget's *Bibliotheca Chemica*, 1702, i. 624; of the *Verosimilia Sacra et Profana* of Hoven and Molfenger, 1732, ii. 93; and of the copy used by Romocki, i. 93. Prof. Brewer's MS. reads *sal petræ*.

name of the wood from which it is made. The *et sic facies* of the second clause shows that there must necessarily be in the first clause, and consequently in the anagram, some verb in the imperative mood, such as *mix* or *take*. We may expect a word for a weight (*libræ*, *unciæ*, &c.), or the word *partes*. As regards the proportions, the earliest we are acquainted with approximate more or less closely to 2 : 1 : 1, Arderne's recipe being merely a laboratory recipe. The proportions of the ingredients, therefore, if included in the anagram, will probably not differ much from 2 : 1 : 1.

Rearranging the letters of the anagram, we get—

RVIIPARTVNOUCORULVET,

or since U and V are interchangeable,

R. VII PART. V NOV. CORUL. V ET; *i.e.*

r(ecipe) vii part(es), v nov(ellæ)[1] corul (i), v et.

The whole passage in the original therefore reads:—

"sed tamen salis petræ recipe vii partes, v novellæ coruli, v et sulphuris," &c.; that is—

"but take 7 parts of saltpetre, 5 of young hazel-wood, and 5 of sulphur," &c.;

i.e. 1$\frac{2}{5}$ sp., 1 char. and 1 sulph.

R. was the common contraction for *recipe*, and may be seen in Marcus Græcus' first recipe (Berthelot's text). *Nov. Corul.* could have presented no difficulty to Bacon's correspondent, seeing that in the previous letter, Cap. X., Bacon had spoken of

[1] "Atque mala vites incidere falce *novellas*."—Vergil, "Bucol.," iii. 11. The word, however, may be simply *novæ*.

virgulti coryli. There he writes *coryli:* in his *Opus Majus* he wrote *coruli* (ii. 219, Bridges ed.).

The second anagram (in Greek, Roman, and Anglo-Saxon letters) seems to be a note to the first and need not detain us, since we have already got the names and proportions of the ingredients.

In deference to those readers who may reject the preceding attempts to read Bacon's riddles, we now proceed to show, on grounds independent of the steganogram and anagram, that Bacon was in possession of an explosive.

The igneous bodies of which Bacon speaks fall into two classes. The first class are incendiaries. "Incendiaries," he tells us, "may be made from saltpetre, or petroleum, or maltha,[1] or naphtha, mixed with other substances. . . . To these are allied Greek fire and many other incendiaries[2]. . . (Burning) maltha, if thrown upon an armed soldier, will cause his death. . . . It is difficult to extinguish, water being useless for this purpose."[3]

But side by side with these passages we find descriptions of igneous compositions of a totally different kind. "There are other natural wonders. We can produce in the air sounds loud as thunder

[1] "Maltha, quæ est genus bitumenis."—*Opus Majus*, London, 1733, p. 474.

[2] "Possumus artificialiter componere ignem comburentem, scilicet, ex sale petræ . . . ex oleo petroleo . . . ex maltha et naphta et consimilibus . . . His vicinus est ignis græcus et multa comburentia."—*De Secretis*, cap. vi.

[3] "Maltha . . . projecta super hominem armatum comburit eum. . . . Ignis comburens fit ex eo qui cum difficultate potest extingui, nam aqua non extinguit."—*Op. Maj.*, as above.

and flashes bright as lightning—nay, even surpassing the powers of nature. A small quantity of (a certain) composition, no bigger than one's thumb, will give forth (on ignition) a deafening noise and a vivid flash."[1] We have, too, the passage, already quoted, in the eleventh chapter, where he says that saltpetre and sulphur and *something else* give forth (on ignition) "a thundering noise and a vivid flash."[2] Again: "Some compositions (when ignited) make an unbearable noise. . . . No other sound can be compared with it. Others produce flashes more fearful to behold than real lightning. . . . We may exemplify these effects with a child's toy which contains within it a quantity of saltpetre (mixture) the size of one's thumb. In the bursting of this bauble, made only of parchment, there are given forth a noise louder than the mutterings of thunder and a flash brighter than the brightest lightning."[3] It

[1] "Sunt alia stupenda naturæ. Nam soni velut tonitrua et coruscationes fieri possunt in aere; imo majori horrore quam illa quæ fiunt per naturam. Nam modica materia adaptata, scilicet ad quantitatem unius pollicis, sonum facit horribilem et coruscationem ostendit vehementem."—*De Secretis*, cap. vi.

[2] See p. 156.

[3] "Quædam vero auditum perturbant . . . Nullus tonitrui fragor posset talibus comparari. Quædam tantum terrorem visui incutiunt, quod coruscationes nubium longe minus et sine comparatione perturbant. . . . Experimentum hujus rei capimus ex hoc ludicro puerili, quod fit in multis mundi partibus, scilicet ut instrumento facto ad quantitatem pollicis humani ex violentia illius salis qui sal petrae vocatur, tam horribilis sonus nascitur in ruptura tam modicæ rei, scilicet modici pergameni, quod fortis tonitrui sentiatur excedere rugitum, et coruscationem maximam sui luminis jubar excedit."—*Opus Majus*, London, 1733, p. 474. "Offenbar ist hier das Schiesspulver verstanden."—L. Schneider, "Roger Bacon," 1873, p. 110. Two

will be evident on a moment's consideration that the charge of this toy must have been an explosive. Had it been an incendiary, the paper would have taken fire long before the pressure of the gases generated by the combustion had increased sufficiently to burst the case, and there would have been no loud report.

The consequences of igniting these two classes of composition are described so clearly as to preclude all possible misunderstanding:—the incendiary *burns* fiercely, while the other mixture gives forth *a bright flash and a loud noise*. In the latter case, Bacon was describing an explosion, and, as he has elsewhere spoken of saltpetre, charcoal, and sulphur, the reasonable conclusion is that the explosive was gunpowder.

It has been said that the first of the foregoing passages—"there are other natural wonders," &c.—describes a rocket. As everybody knows, a rocket in its flight makes a whizzing noise and is followed by a trail of heated gas and sparks. The whizzing noise can only be compared to thunder by a total disregard of fact, for no sound resembles thunder less. Does thunder whizz? The fiery trail can only be called a flash by an equal disregard of fact: it gives a continuous light. But if the rocket carries a bursting charge which explodes in mid-air,

centuries before, when referring to Bacon's remarks on the destruction of the Midianites by Gideon, Borrichius had said: "Hic apertissime loquitur Bacon de nitrato illo sclopetorum pulvere."—*De Ortu &c., Chemiæ*, 1668, p. 126.

the explosion may, with venial exaggeration, be said to produce a flash like lightning and a noise like thunder. Bacon was alluding to a bursting charge consisting of an explosive, and that explosive was gunpowder.

Was Bacon aware of the projective force of gunpowder? There is nothing in his works (so far as I am acquainted with them) which suggests that he was. He knew that gunpowder exploded, and he believed that an army might be either actually blown up by it, or put to flight by the terror inspired by its explosion;[1] but he seems to have gone no further. He experimented, probably, with very small quantities of it; and the behaviour of gunpowder when fired in large quantities under pressure is so unlike its behaviour when fired in small quantities in the open air, that its projective force could neither have been predicted by abstract reasoning nor realised by even his powerful imagination.

If a surmise be permissible, Bacon did not invent, he discovered gunpowder. Experimenting with some incendiary composition, prepared with pure instead of impure saltpetre, the mixture exploded unexpectedly and shattered all the chemical apparatus near it, thereby laying the foundation of the mediæval legend about the destruction of the Brazen Head. This suggestion, if correct, only adds one more item to the long list of accidental

[1] This is M. Berthelot's view; *Sur la Force des Matières Explosives*, Paris, 1883, ii. 358; and it is probably the right one.

discoveries. The laws of the structure of crystals were discovered by Haüy's accidentally letting fall a piece of calc-spar, which broke into fragments. Malus, chancing to look through a double refracting prism at the light of the setting sun, reflected from the windows of the Luxembourg Palace, discovered the polarisation of light. Galvani discovered galvanism by mere accident. The decomposition of water by voltaic electricity was accidentally discovered by Nicholson in 1801.

However, whether as discoverer or inventor, Roger Bacon made and fired the first gunpowder. It fell to the lot of a persecuted English monk to fulfil the prophecy of Prometheus, that in the latter day there should appear "a wondrous being, who should call forth flashes brighter than lightning and sounds louder than thunder." [1]

[1] . . . δυσμαχώτατον τέρας·
ὃς δὴ κεραυνοῦ κρείσσον' ἐυρήσει φλόγα,
βροντάς θ ὑπερβάλλοντα καρτερὸν κτύπον.
—ÆSCHYLUS, *Prometheus Vinctus*, 921.

PART II

THE PROGRESS OF AMMUNITION

General Monnet, protested against their use. They did good service at the passage of the Adour in 1813, and at the battle of Leipsig, where Captain Bogue, who commanded the Rocket Brigade, was killed. A French infantry brigade in the village of Paunsdorf, "unable to withstand the well-directed fire (of rockets), fell into confusion, began to retreat," and ultimately surrendered to the Rocket Brigade.[1] Two years afterwards, at Waterloo, the rockets, under Sergeant Daniel Dunnett, proved very effective.

Of late years rockets have fallen into disrepute everywhere, owing to radical defects explained by Captain C. O. Browne, R.A.;[2] and their use is unlikely to be revived until the chemists make some unforeseen and astonishing discovery.

[1] "Capt. Bogue and the Rocket Brigade," by Col. F. A. Whinyates, late R.H.A., in "Proceed. R.A. Institution," vol. xxiv.

[2] "Ammunition," as above, pp. 175–76.

CHAPTER XII

GUNPOWDER

THE oldest recipe for gunpowder is Roger Bacon's. If the solution of his anagram which I have ventured to propose be accepted, the proportions of the ingredients in 100 parts were:—

Saltpetre.	*Charcoal.*	*Sulphur.*
41.2	29.4	29.4

The French recipe of 1338 being incomplete (Table VIII.), the next complete recipe for gunpowder is that given in the MSS. of Dr. John Arderne of Newark, who began to practise as a surgeon before 1350:[1]— "Pernez *j. li.* de souffre vif; de charbones de saulx (i. weloghe) *ij. li.*; de saltpetre *vj. li.* Si les fetez bien et sotelment moudre sur un pierre de marbre, puis bultez le poudre parmy vn sotille couerchief; cest poudre vault à gettere pelottes de fer, ou de plom, ou d'areyne,[2] oue vn instrument qe l'em appelle *gonne*." This gives in 100 parts:—

Saltpetre.	*Charcoal.*	*Sulphur.*
66.6′	22.2′	11.1′

[1] Sloane MSS., 335, 795; and Freind's "Hist. of Physick," 1758, ii. 325.

[2] "Bombardes, basilics, jettans boullets de fer, de plomb, de bronze."—Rabelais (d. 1553), iv., c. 61.

The word *gonne*, in the sense of cannon, must have been commonly known during the last quarter of the fourteenth century; for Chaucer uses it with this meaning in the "Hous of Fame," iii. 553, cir. 1380—

> "As swift as pelet out of gonne,
> Whan fyr is in the poudré ronne;"

and Langley uses it with the same meaning in the C text of his "Vision of Piers Plowman," xxi. 293, *cir.* 1393:—

> "Set bows of brake and brasene gonnes,
> And shoot out shot enough his sheltrums to blend."

Now the explanatory phrase, "qe l'em appelle gonne," shows that *gonne* was but little known when the above recipe was written. We may therefore date it at 1350.

It will be observed that down to the word *marbre*, the recipe is a literal translation of a receipt for rocket composition given by Marcus Græcus.[1] Yet the two powders, although made of *nominally* the same ingredients in the same proportions, did not produce the same effects when fired; for gunpowder will not propel a rocket, and rocket composition will not project a cannon-ball. The difference in their effects was probably due to the researches of Roger Bacon, who had discovered the importance of using pure saltpetre and of thoroughly

[1] Recipe 13. Extracts from Arderne's MSS. given by Hewitt, "Ancient Armour," ii. 284, leave little doubt that Arderne was acquainted with the *Liber Ignium* of Marcus Græcus.

incorporating the ingredients. It is improbable that Arderne's recipe represents the powder used in the cannon of his time. Its proportions are so entirely out of keeping with those of the French powder of 1338 (Table VIII.) and those of Whitehorne's powder of 1560 (Table VII.), that we may regard it as no more than a laboratory receipt.

It needed but little experience to show how far short of perfection serpentine powder fell.

While the fouling of dry, well-incorporated powder is comparatively trifling, a damp or slow-burning powder, such as serpentine, leaves a much larger residue. The consequence was that, after a few rounds, it was exceedingly difficult to reload small arms, a considerable part of the loose, floury charge sticking to the fouling.[1] The remedy for this evil was the use of cartridges. Whitehorne mentions "bagges of linnen or paper" for the charges of cannon in 1560,[2] and in 1590 Sir John Smythe speaks not only of cartridges, but of composite cartridges for small arms—"cartages with which (musketeers) charge their peeces both with powder and ball at one time."[3]

There are payments for talwood (faggots) "for drying powder" in the English store accounts 1372–74,[4] and in 1459 the Scotch Government were

[1] In the Peninsular War, our men could fire over 100 rounds, the French only 50, without washing out the barrels of their muskets. Marquis de Chambray, *Œuvres*, v. 293–4.

[2] Fol. 33.

[3] "Certain Discourses . . . concerning Divers Weapons," p. 20.

[4] Sir H. Nicolas, "Hist. of Royal Navy," ii. 479.

endeavouring to keep their powder dry by storing it in waxed canvas bags.[1] An official recommends the English Privy Council in 1589 to sell certain "bad powder" at Dorchester, adding, "the longer it is kept the worse yt wilbe."[2] The Navy were of course, then and always, the chief sufferers from damp powder. Serpentine powder, Sir Henry Manwayring tells us in 1664, was never taken to sea (after big guns had become strong enough to stand corned powder) "both because it is of small force, and also for that it will, with the aire of the sea, quickly drie and lose its force."[3] But corned powder was by no means proof against damp. In the action fought off Grenada in July 1779, Bishop Watson says "the English shot would not reach" the French. The powder, it was found, "had concreted into large lumps, in the middle of which the saltpetre was visible to the naked eye."[4] Between the years 1790 and 1811, 189,000 whole barrels of powder, "which had formed into lumps from the damp of H.M.'s ships of war," and had consequently been returned into store as useless, were rendered serviceable in the Government powder factory.[5]

[1] "Pro tribus petris cere . . . ad cerandum canubium ad arificiendum pulveris bumbardorum in castro de Edinburgh," &c. "Chronicles of Scotland," published by the Deputy Clerk-Register, vi. 495–97. In these documents a cross-bow is called, "arcus cum circulo."

[2] "Acts of (English) Privy Council," N.S., xvii. 392.

[3] "Seaman's Dictionary," under "Powder."

[4] "Chemical Essays," 1781, ii. 10. This led to a Parliamentary inquiry.

[5] "A Statement of Facts," &c., by General Sir W. Congreve, 1811, pp. 18–19.

Being merely a loose mechanical mixture of three substances with different specific gravities, serpentine powder had a tendency, when shaken in transport, to resolve itself into three strata, the heaviest substance (the sulphur) settling down to the bottom, and the lightest (the charcoal) remaining at the top. This meant, practically, that on coming into the enemy's presence the ingredients had to be incorporated afresh. To save trouble, and to avoid the danger of a second mixing, it was for a long time customary to carry the ingredients separately,[1] or, at least, to carry the charcoal apart from the saltpetre and sulphur. There was another argument, however, in favour of this course. While serpentine powder, however tightly secured, gave out a large quantity of impalpable dust which might cause an explosion at any moment, no explosion was possible so long as the ingredients were kept asunder. But whatever was the reason for resorting to such an expedient, it is evident that the remedy was nearly as bad as the disease.

Serpentine powder had another drawback,—it required very careful ramming home. "Thrust the pouder home fair and softly," says Whitehorne.[2] "The powder rammed in too hard and the wad also," says Bourne in 1587, "it will be long before the peece goeth off. . . . The powder too loose . . . will make the shotte to come short of the mark. . . . Put up the powder with the rammer head

[1] Brackenbury, iv. 292.

[2] Fol. 33.

somewhat close, but beat it not too hard."[1] By beating it too hard the interstices between the particles through which the flame permeated the charge were diminished in size, and if beaten sufficiently hard the mixture tended to become a solid which burned away without exploding. Finally, the combustion of serpentine, at the best, was so slow that a large volume of its gas escaped wastefully through the vent.

These evils were in some cases much lessened, and in others quite got rid of by the gradual introduction of corned powder, which is mentioned in 1429 in the Firebook of Conrad von Schongau,[2] and was in use for hand-guns in England long before 1560. Corned powder (1) deposited less fouling than serpentine; (2) it was less susceptible to damp, especially after the introduction of glazing;[3] (3) it did not resolve into strata in transport; (4) it gave out less dust; (5) it was much less affected by hard ramming; (6) owing to the larger interstices between the grains,[4] it burned so quickly that there was little or no waste of gas through the vent, and it was consequently so strong that 2 lbs. of corned did the same work as 3 lbs. of serpentine powder.[5] It was,

[1] "Art of Shooting in Great Ordnance," p. 2.

[2] Jähns, p. 804.

[3] Mieth mentions glazing in 1684; *Artilleriæ Recentior Praxis*, Franckfurt, pt. ii. c. 55.

[4] This is the only reason given by Clarke for the introduction of corned powder. "Natural History of Nitre," 1670, p. 88.

[5] "Das knollen bullfer ij pfund mer tud denn gereden bullfer iij pfund." Firebook, 1400–50, in Romocki, i. 182.

in fact, too strong for cannon for a long period: Chemistry had outrun Metallurgy. "If serpentine pouder should be occupied (used) in handguns," says Whitehorne, "it would scant be able to drive their pellets[1] a quoit's cast from their mouths; and if handgunne (*i.e.* corned) pouder should be used in pieces of ordnance, without great discretion, it would quickly break or marre them."[2] Here we have the cause which necessitated the general retention of serpentine powder for cannon until the first half (or middle) of the sixteenth century, after which it is heard of no more except for secondary purposes, such as priming, &c. We must not overlook the importance of Whitehorne's remark. He was an educated man of sound, practical sense, who had been a student of Gray's Inn, and whose experience was not confined to the English Artillery, for he had seen service in the Low Countries. What he says is a sufficient safeguard against inferring too much from Schongau's mention of corned powder in 1429. It came slowly into use for hand-grenades and small arms in the fifteenth century; but no country then possessed cannon strong enough to stand its explosion, and it did not come into general use for another century.

[1] "'Of a verity the shooting of the foemen doth begin to increase,' exclaimed the Rev. Gabriel Kettledrummle; 'peradventure some pellet may attain unto us even here. Lo! I will ensconce me behind the cairn, as behind a strong wall of defence.' 'He's but a coward body after a',' said Cuddy; 'he's but a daidling coward body.'" "Old Mortality," chap. xvii.

[2] Chap. xxiv.

In addition to its being at first too strong for big guns, corned powder had the disadvantage of being dearer than serpentine. The latter was sold in 1569 at £80 the last (2400 lbs.); the former in 1570 at £90.[1] The following Table gives the price of English powder at various times:—

TABLE V.

Price of English Gunpowder per lb.

Nature.	1347	1378	1462[2]	1482[3]	1569[4]	1578[5]	1588[6]	1595[7]	1695[8]	1865[9]
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
Serpentine	13¾	13⅔	12	10	8	...	....	...	...	...
Corned .	...	...	...	...	9	10	12	13	10¾	7
Fine . .	...	...	...	...	...	11	...	...	...	...

The remarkable uniformity in the prices of English powder has been noticed by Prof. Rogers in his "History of Agriculture and Prices," iv. 631. He thinks that "fine" powder meant priming powder, because infantry soldiers were usually served out with 1 lb. "common" (corned) powder and ¼-lb. "fine" powder. It doubtless did at one time; but the term was applied to all small-arm powder eventually.[10]

[1] Prof. J. E. Thorold Rogers, "History of Agriculture and Prices," 1866, iii. 578–79.
[2] Rogers, "History of Agriculture and Prices," iii. 556.
[3] Ib., 558. [4] Ib., 578. [5] Ib., 581.
[6] "Acts of Privy Council," 1588, N.S., xvi. 146.
[7] Ib., 28th December 1595, xxv. 137.
[8] Rogers, v. 752. [9] Waltham Abbey.
[10] "Fyne corne powder for small shot." "Acts of Privy Council," 8 Ap., 1588; xvi. 25.

The prices of the first two powders have necessarily been calculated. The price of charcoal in 1347 was .013d. per lb.; in 1378 it was .02d.[1] The prices of sulphur and saltpetre in 1347 were 8d. and 18d. per lb. respectively;[2] in 1378 they were (for large quantities) 4d. and 20d. respectively.[3] From an English MS., quoted by the Emperor Napoleon III., it appears that the cost of manufacturing powder at Southampton in 1474 was .864d. per lb.;[4] and, as it is the only fact available, I have been obliged to assume that this was the cost of making powder in 1347 and 1378. But it is probably not far from the truth. The proportions taken for the 1347 powder are Arderne's, 6-2-1; those for 1378, 3-1-1. From these data we have:—

1347.	*d.*	1378.	*d.*
6 lbs. saltpetre . .	108.	3 lbs. saltpetre . .	60.
2 „ charcoal . .	.026	1 lb. charcoal . . .	.02
1 lb. sulphur . . .	8.	1 „ sulphur . . .	4.
Price of 9 lbs. of materials	116.026	Price of 5 lbs. of materials	64.02
„ „ 1 lb. „ „	12.892	„ „ 1 lb. „ „	12.80
Cost of making, per lb.	.864	Cost of making, per lb. .	.864
Price of 1 lb. . .	13.756	Price of 1 lb. . .	13.664

The price of French powder in 1375 was 120d. per lb.;[5] but in order to be able to compare it with

[1] Rogers, i. 454.
[2] Rev. J. Hunter in *Archæologia*, xxxii. 382, who quotes the payments made by Wm. de Stanes in the Wardrobe Accounts of Edward III.
[3] Rogers, ii. 754.
[4] Ib., iii. 205.
[5] Ib., iv., *Pièces Justificatives*, No. 6, p. xliv.

the price of English powder in 1378, we must know the ratio of French to English money at that period. The French Troyes livre then contained 5760 gs.; the English Tower pound 5400 gs. Therefore—

1 livre (pure silver) = $\frac{16}{15}$ pound (pure silver).

Under Philip of Valois (1328–50) the livre was debased to $\frac{1}{12}$ its original value,[1] and almost simultaneously the pound was debased by Edward III. to $\frac{4}{5}$ its primitive value.[2] Or 1 good livre was worth 12 bad livres, and 1 good pound was worth $\frac{5}{4}$ of a bad pound. Therefore—

12 livres = $\frac{16}{15}$ ($\frac{5}{4}$ pound) = $\frac{4}{3}$ pound; or
9 livres = 1 pound.

Dividing the price of 1 lb. French powder, 1375, by the price of 1 lb. English powder, 1378, we get 120/13.664 = 8.7; so that the French powder at this period was somewhat cheaper than the English. As the purchasing power of fourteenth-century money was about ten times that of ours, the French powder of 1375 cost about 11s., and the English powder of 1378, 11s. 4½d. per lb.

The high price of early gunpowder resulted from high freights and (in the case of saltpetre) the rapacity of Eastern merchants. We may form

[1] Hallam's "Middle Ages," i. 211. On the accession of Louis XI. (1461) "the livre was only about $\frac{1}{15}$ of its original value . . . and in 1789 the livre had come to be only $\frac{1}{78}$ of its weight in the time of Charlemagne. "Money," by Prof. Bastable, in *Ency. Brit.*, 9th ed., xvi. 727.

[2] "Treatise on the Coins of the Realm," by (the first) Lord Liverpool, reprinted London, 1880, p. 40.

some notion of the price they exacted for their saltpetre which cost them little,[1] from the price they put upon their naphtha which cost them next to nothing. "Another fountayne there is towarde the Oryent whereof is made fyre grekysshe, with other myxtyons (mixtures) that is put thereto; the which fyre when it is taken and lyght is so hote that it can not be quenched with water, but with aysel (vinegar), urine or sande only. The Sarasynes sell this water dere, and derer than they do good wyne."[2]

The manufacture of gunpowder soon became a trade. We find a powder-mill in Ausburg in 1340, in Spandau in 1344, and in Liegnitz in 1348.[3] There was a gunmaker in Stockholm in 1430, who was very probably a powder-maker too;[4] and it is certain that there was a powder-maker there in 1464 — Mäster Berend.[5] Nor were Governments blind to the importance and the profit of the trade. Beckmann states that the Archbishop of Magdeburg in 1419 only permitted the collection of saltpetre on payment of a license,[6] and Clarke informs us that the Pope and the Archduke of Bavaria engaged

[1] In 1580 saltpetre was selling in the north-west of India at a half-penny a pound. "Manufacture of Gunpowder," Col. W. Anderson, 1862, p. 16.

[2] Caxton's "Myrrour and Description of the Worlde," 1480, Part II., c. 21.

[3] M. Berthelot in *Revue des Deux Mondes*, 15th August 1891, p. 817.

[4] *K. Vitterhets Hist. och Antiq. Acads. Handr.*, Stockholm, iv. 337.

[5] Kapten F. A. Spak's *Öfversigt öfver Artilleriets Uppkomst och Utveckling i Europa*, p. 12.

[6] "History of Inventions," Bohn's ed., ii. 509.

themselves in powder-making at an early date.[1] Louis XI. appointed commissioners in 1477 to collect all the saltpetre they could find, with power to force an entry wherever they suspected it was stored.[2]

During the Ancient Period, say 1250–1450, when serpentine was exclusively used, one powder could only differ from another in composition, that is, in the proportions of the ingredients used, supposing them to be equally pure; during the Modern Period, say 1700–1886, the powders used (in each individual State) differed only, as a general rule, in the size of the grain;[3] during the Transition Period, 1450–1700, they generally differed both in composition and grain.

The proportions of the ingredients were quite arbitrary during the Ancient Period, and not only Governments, but private manufacturers, had their special recipes. As late as 1628 Norton says there were "infinite recipes for making of powder, but most states have enjoyned a certain proportion."[4]

The introduction of corning, far from curbing the lawlessness of the Ancient Period, made confusion worse confounded. *Then* there was but one variable—the proportions of the ingredients; *now* a second independent variable was introduced—the size of the grain. But a reaction was at hand,

[1] "Natural History of Nitre," London, 1670, p. 21.
[2] Napoleon III., iii. 205.
[3] There were exceptions, such as blasting powder.
[4] "The Gunner," p. 145.

which set in first in France, where corned powder had been adopted in 1525.[1] It appears to have been noticed during the second half of the fifteenth century that large-grained powder was the fittest for big guns, and this fact the French utilised in 1540 by officially restricting the service powders to three, of uniform composition but different-sized grains.[2]

The largest-grained powder was used for the largest guns, and the composition was 80.7 salp., 11.5 char., and 7.8 sulph., which closely corresponded to Whitehorne's (corned) hand-gun powder —78.3 salp., 13 char., and 8.7 sulph.[3] It may be questioned, however, whether the French, official injunctions notwithstanding, confined themselves very religiously to powders of uniform composition. Boillot, whose work was published at Chaumont in 1598, says the grain for big guns was as large as a pea, that for medium guns the size of hempseed, and that for serpents, &c., still smaller. But from a remark he makes on reaching the manufacture of powder—"vous viendrez à la composition (de la pouldre), mais par poix et mesure, selon que vous voudrez faire les pouldres"[4]—it is clear that powders for all purposes were not of the same composition.

During the first half of the seventeenth century the French official powder was weaker than the above—75.6 salp., 13.6 char., and 10.8 sulph.—and

[1] Jähns, 804 *n.* [2] Napoleon III., iii. 232. [3] Chap. 24.
[4] *Modelles, Artifices de feu*, &c., pp. 95, 97.

for big guns had grains as large as hazel-nuts.[1] At Pont-à-Mousson, just across the German border, powders of different compositions were in use in 1620;[2] and east of the Rhine powder for different guns probably varied in grain, and certainly varied in composition. "Of the various powders now made," says Furtenbach in 1627, "the following are generally employed:[3]—

Saltpetre.	Charcoal.	Sulphur.
69.0	16.5	14.5 for big guns;
72.4	14.5	13.1 for small guns;
75.7	13.0	11.3 for small arms."

The information given to us about granulation by the early English gunners is neither clear nor full.

When Whitehorne tells us that the method of corning "all sorts of powder" was the same, namely, by means of a sieve and a few heavy metal balls,[4] what meaning did he intend to convey by the phrase "all sorts of powder"? There can be little doubt that he meant "powders of whatever composition, and whatever the size of the grain to be produced;" first, because it would be preposterous to assume that all the sieves of his time had meshes

[1] Napoleon III., iii. 329.

[2] "Receuil de Plusieurs Machines Militaires et Feux d'Artifices pour la guerre." De la diligence Thybovril et J. Appier dit Hanzelet; Pont-à-Mousson, 1620, liv. iv. p. 12.

[3] "Nun werden unterschiedliche Pulver gemacht, jedoch aber allein drey Sorten zum meistens gebraucht." *Halinitro Pyrbolia*, Ulm, p. 6.

[4] Chap. xxiii. fol. 28.

of equal size; and secondly, because there is abundant evidence to show that, long after Whitehorne's time, the powders for different guns in England (and elsewhere) varied both in composition and grain. In 1620 Thybovril and Hanzelet tell us that powder to be granulated is to be passed through a sieve with holes "de la grosseur que vous desirez votre poudre";[1] and eight years afterwards Norton uses the very same ambiguous phrase, "a syve . . . made full of holes of the bignesse you desire your cornes."[2] Did they mean that the size of the grain in their time was purely arbitrary and might be of any magnitude whatever? A passage in Boillot's (earlier) work explains their meaning much better than they have done it themselves. He first tells us that the sieve is to have holes "de telle grosseur que vous voudrez," and he then goes on to explain the proper size of grain for use in the different classes of ordnance, as given here on a previous page. In a word, three or four kinds of sieves (differing in the size of their meshes) were procurable—some for graining powder for big guns, others for graining powder for medium guns, &c. &c.—and having fixed upon the gun from which your powder (when grained) was to be fired (and consequently upon the size of the grain), you were to select those sieves which had meshes "of the bignesse you desired your cornes."

[1] "Receuil de Plusieurs Machines Militaires et Feux d'Artifices," &c., Pont-à-Mousson, 1620, p. 14.

[2] "The Gunner," p. 145.

From the phrase used above by Norton, it is certain that several powders, differing in grain, were in use when he wrote; from the evidence of Norton,[1] Nye,[2] and others, it is equally certain that several different receipts for making powder were in use during their time. The conclusion is that during the first half of the seventeenth century powders made in England for different guns varied both in composition and size of grain.

The lawlessness in composition and grain during the greater part of the Transition Period was the natural consequence of the absence of any instrument to measure the comparative strength of different powders, and enable gunners to establish some standard for the proportions of the ingredients and the size of the grain.

The earliest instrument proposed for testing the strength of powder was, I believe, Bourne's "engine or little boxe," which, he says, was "very necessarie to be used."[3] Whether he invented it himself or not, it is impossible to say: he tells us, "some of (the inventions) I have gathered by one meane and some by another, but the most part of them hath been mine own."[4] The engine was a wretched one. The powder to be tested was ignited in a small metal cylinder with a heavy lid (working on a hinge) which when raised could not shut of itself. The angle through which the lid was raised by the explosion indicated the strength of the powder.

[1] "The Gunner," p. 145. [2] pp. 4, 5.
[3] "Inventions and Devices," 1578; No. 54, "Art of Shooting," &c., p. 28. [4] Ib., Preface.

A better instrument was that described by Furtenbach in 1627.[1] It differed from Bourne's "little boxe" in that the lid was only laid upon the cylinder. When the powder exploded the lid was blown upwards along two vertical wires which passed through it; but it could not descend again of itself, being held in the place it reached by iron teeth (like those which supported the lid of Bourne's box). Nye describes this instrument, and suggests that the comparative strength of powders should be further tested by measuring the penetration of pistol balls into clay, and the ranges of projectiles fired from a small mortar.[2] This is, I believe, the first proposal of the *mortar éprouvette*, 1647. The French certainly adopted them before 1686, often though it has been said that they then introduced them. On the 18th September of this year Louis XIV. published an ordonnance complaining of "the variety of eprouvettes" in use for testing powder, and directing that for the future no powder should be accepted unless 3 oz. of it could throw a ball of 60 lbs. 50 toises (320 ft.) from the Government pattern mortar.[3] In a previous ordonnance (April 16, 1686) the King had protested against the bad charcoal (*de méchante qualité*) constantly employed; against impure saltpetre (*rempli de graisse et de sel*), insisting upon the exclusive use of saltpetre "de trois cuites"; and against insufficient incorporation (*dix ou douze heures . . . au lieu de . . . vingt quatre heures*).[4] But he marred the

[1] *Halinitro Pyrbolia*, Ulm, 1627, p. 9. [2] Chap. xvi. p. 29.
[3] Napoleon III., iv. 54. [4] Ib., 53.

reforms he made by taking the unaccountable step of introducing one powder, of the same composition and size of grain, for all arms.[1] For this blunder the French afterwards paid in blood, especially during the Peninsular war.[2]

About the beginning of the eighteenth century most countries had reduced their powders to two or three, which were of the same composition, and differed only in grain. In 1742 Benjamin Robins, by his "New Principles of Gunnery," placed gunnery upon a strictly scientific basis, and by his epoch-making invention of the ballistic pendulum[3] enabled gunners for the first time to measure the muzzle-velocity of projectiles with considerable accuracy. It may have been owing to the lessons taught by this instrument that, between 1742 and 1781, we changed the proportions of the ingredients of our powder from 75—12½—12½ to 75—15—10. Profiting by the rapid progress of electricity during the first half of the nineteenth century, Sir Charles Wheatstone proposed in 1840 his electro-magnetic chronoscope,[4] which registered to the $\frac{1}{720}$ part of a second, to replace Robins' ponderous pendulum.

[1] "Traité . . . de fabriquer la Poudre," &c. Bottée and Riffault, 1811, p. lij. [2] Marquis de Chambray, *Œuvres*, v. 293–4.

[3] "Dieses Pendel wurde mit Recht als ein epochmachende Erfindung bezeichnet." Gen. H. Müller, *Entwickelung der Feldartillerie*, Berlin, 1893, i. 23. To save the time of any of my readers who wish to read Gen. Müller's remarks on our Artillery, I may mention that they will not be found under the heading "England," but under the comprehensive heading *Die kleineren Staaten*, grouped with Greece, Switzerland, &c., ii. 272.

[4] See Wheatstone's own account of his instrument in the *Comptes Rendus de l'Acad. des Sciences*, 1845, tom. xx. pp. 1554–61.

Wheatstone's instrument was not adopted by our Government, but his idea was followed up and improved upon by Captain Navez, of the Belgian Artillery, who in 1847 brought forward his electro-ballistic pendulum.[1] Only one instrument was now wanting to enable the mechanical effect of the explosion to be directly and completely observed—an instrument to measure the pressure upon the bore of the gun; and this want was supplied in 1861 when Captain T. J. Rodman, Ordnance Department, United States Army, produced his Indenting Apparatus and his Internal Pressure Gauge.[2] The following Table gives the results of some experiments with the new instruments:—

TABLE VI.

Showing the connection between the Size of the Grain, Muzzle Velocity, and Pressure on Bore.

Diameter of Grains. Ins.	Charge. Lbs.	Weight of Shot. Lbs.	Muzzle Velocity. F.s.	Pressure on Bottom of Bore. Tons per Sq. In.
.1	8	.43	1261	21.5
.15	"	"	1235	21.0
.2	"	"	1199	18.8
.25	"	"	1151	17.1
.3	"	"	1146	15.3
.4	"	"	1187	14.2

[1] "Nous reconnaissons, avec l'abbé Moigno, que M. Wheatstone a eu le premier l'idée de la belle application dont il est ici question. . . . Il a fallu du temps et du travail pour rendre féconde, dans les expériences d'Artillerie, la belle idée de M. Wheatstone." Cap. Navez, *L'Application de l'Electricité à la mesure de la Vitesse des Projectiles*, Paris, 1853, pp. 4, 5.

[2] "Report on Experiments on the Properties . . . of Cannon Powder," Boston, Mass., 1861, pp. 174, 299. Table VI. is taken from this Report.

This Table shows that as the size of the grain slowly increases, the muzzle velocity decreases very slowly, and the pressure on the bore decreases very quickly. The consequence of this discovery was the manufacture of various very large grained powders such as pebble powder, &c., for heavy guns. But the thorough knowledge of the mechanical effect of the explosion of gunpowder gained by the use of the Navez and Rodman instruments, was of little avail to anybody, for gunpowder had nearly run its course. Just twenty-five years after the introduction of the pressure gauge M. Vieille put the French Government in possession of a nitrocellulose explosive,[1] and gunpowder was added to the list of things that were.

Throughout the whole gunpowder period enthusiasts seem never to have been wanting who believed in the possibility of making smokeless powder and noiseless powder. Castner's powder, which contained only 3 per cent. sulphur, seems to have been the nearest approach to the former, but no powder containing sulphur could be absolutely smokeless. Whether early gunners suspected this or not I do not know; certain it is, however, that sulphurless powder was under discussion centuries ago. Rabelais (who may have heard soldiers talking about the matter) alludes jokingly to "pouldre de canon curieusement composée, degressée de son soulfre."[2] In 1756 the French actually experimented with sulphurless mixtures, one of which (80 per cent.

[1] 1886. [2] Bk. IV., *c.* 62.

sulph. and 20 per cent. ch.) gave good results in range, with very little smoke. It proved to be worthless for military purposes from the difficulty of corning it, and from its crumbling to dust during ordinary transport.[1] The belief in a noiseless powder was scoffed at by Whitehorne: "There be many who bring up lies, saying that they can tell how to make pouder that shooting in gunnes shall make no noise, the which is impossible." A century afterwards Sir Thomas Browne believed means might be adopted, if not to stifle the sound altogether, at least "to abate the vigour thereof, or silence its bombulation."[2]

Tables VII. and VIII. give the composition of gunpowder at various times.

TABLE VII.

English Gunpowder.

	1250[3] *cir.*	1350[4] *cir.*	1560[5]	1647[6]	1670[7]	1742[8]	1781[9]
Saltpetre	41.2	66.6′	50.0	66.6′	71.4	75.0	75
Charcoal	29.4	22.2′	33.3′	16.6′	14.3	12.5	15
Sulphur	29.4	11.1′	16.6′	16.6′	14.3	12.5	10

[1] Romocki, ii. 7–10.
[2] "Vulgar Errors," 1648, Bk. II., *c.* 5.
[3] Roger Bacon's powder, see chap. viii.
[4] Doctor Arderne's powder, a laboratory receipt.
[5] Whitehorne's "ordinary" common powder, chap. xxiii., fol. 28.
[6] Nye, pp. 4, 5.
[7] Sir James Turner's *Pallas Armata*, 1670, p. 188.
[8] Robins' "New Principles of Gunnery," 1742, p. 120.
[9] Bishop Watson's "Chemical Essays," 1781, ii. 16.
N.B.—All these writers give the proportions of gunpowder in their own times.

TABLE VIII.

Foreign Gunpowder.

	France[1] 1338	Sweden[2] 1560	Germany[3] 1595	Denmark[4] 1608	France[5] 1650	Sweden[6] 1697	Germany[7] 1882
Saltpetre	50	66.6′	52.2	68.3	75.6	73	78
Charcoal	?	16.6′	26.1	23.2	13.6	17	19
Sulphur	.25	16.6′	21.7	8.5	10.8	10	3

[1] MS. in *Bib. Nat.*, Paris, given in Lacabane's *Bib. de l'École des Chartes*, 2 ser., i. 51. The quantity of charcoal is not given.

[2] Spak's *Öfversigt öfver Artilleriets Uppkomst*, &c., Stockholm, 1878–81, p. 66.

[3] Ib., p. 62. Spak gathers from Fronsperger that the manufacture of powder in Germany was in a very backward state during the second half of the sixteenth century: "att kruttillverkning i Tyskland äfven under senare hälften af 1500-talet befann sig på en särdeles primitiv ståndpunkt, framgår af Fronspergers beskrifning öfver krutets korning." A Brandenburg MS. of 1597 gives a powder of 73.5 : 13.7 : 10.8, but this must have been for small arms. C. von Decker's *Geschichte des Geschützwesens*, &c., 1822, p. 87, powder No. 31.

[4] Blom's *Kristian d. IV.'s Artilleri*, Copenhagen, 1877, p. 49.

[5] Napoleon III., iii. 329. The grains of this powder were as large as hazel nuts.

[6] Spak, p. 166.

[7] Castner's cocoa powder, ballistically the best powder ever made. Romocki, ii. 31.

CHAPTER XIII

SHOCK PROJECTILES

THE nature of the first Artillery projectiles was determined by the nature of the small-arm missiles in use when cannon were introduced by the Germans. To use the bulky and ponderous projectiles of the machines in these small and feeble pieces was out of the question; nothing remained, therefore, but to adopt the darts, bolts, or quarrels which produced such deadly effect when shot from cross-bows:—

> "Of Arblasters grete plenté were,
> Noon armure myght her stroke withstonde."[1]

Darts.

The iron darts feathered with brass—"garros ferrés et empanés en deux cassez"—which are mentioned in the earliest document relating to Artillery that has been found in France,[2] dated 1338, belonged unmistakably to the same family as those used for cross-bows. The brazen feathers were nailed to the shaft, and the missile, which weighed about 7 oz.,[3]

[1] "Romaunt of the Rose," 4196, attributed to Chaucer.

[2] *Original Parchemin parmi les titres scellés de Clairambault*, xxv. fol. 1825; Bib. Nat., Paris (in Brackenbury, iv. 291).

[3] Estimated by Sir H. Brackenbury.

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