GUNPOWDER AND AMMUNITION

THEIR ORIGIN AND PROGRESS

BY

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PART I

THE ORIGIN OF GUNPOWDER

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CHAPTER I

INTRODUCTION

I

MUCH discussion has been caused in the past by the vagueness of the word *gunpowder*. The following are the meanings which this and a few other words bear in these pages :—

Explosion.—The sudden and violent generation, with a loud noise and in a time inappreciable by the unaided senses, of a very great volume of gas, by the combustion of a body occupying a comparatively very small volume.

Progressive Combustion. — Combustion which takes place in a time appreciable by the unaided senses, such as that of rocket composition or a bit of paper.

Gunpowder.—A mixture of saltpetre, charcoal, and sulphur, which explodes. The signs of its explosion are a bright flash, a loud noise, and a large volume of smoke.

Incendiary (for "incendiary composition").—A substance or mixture which burns progressively, although fiercely, and is hard to put out.

Machine always means an apparatus of the ballista type.

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Cannon includes bombards, mortars, guns, &c.
Musket includes all hand firearms charged with gunpowder.

II

Of the many difficulties that beset the present inquiry, two deserve special mention.

The first is the want of simple exactness in most early writers when recording the facts from which we have to draw our conclusions. At times their descriptions are so meagre that it is difficult, if not impossible, to decide whether certain projectiles were incendiary or explosive. At other times they abound in tropes and figures of speech which amount to an unintentional *suggestio falsi*. "The missiles spread themselves abroad like a cloud," says a Spanish Arab; "they roar like thunder; they flame like a furnace; they reduce everything to ashes."[1] A projectile full of blazing Greek fire appeared to Joinville to be of portentous bulk. It flew through the midnight sky with thundering noise like a fiery dragon, followed by a long trail of flame; and it illumined the whole camp as with the light of day.[2] Even to approach the truth, we must prune such figures of rhetoric; and this is a dangerous operation, for we may prune too much. The

[1] Escorial MS., No. 1249, given in Casiri's *Bibliotheca Arabico-Hispana Escur.*, ii. 7.

[2] *Hist. du Roy Saint Loys*, Paris, 1668, p. 39. He calls the projectile "ung tonneau," which it probably was. See the section on "Incendiary Fireballs."

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only safeguard against these suggestive metaphors is to keep steadily in view the distinctive peculiarities of incendiary and explosive projectiles.

The incendiary shell was simply an envelope intended to convey into the interior of a fort, ship, &c., a quantity of combustible matter, which burned with such violence as to *set fire* to everything inflammable that was near it. The primary object of the explosive shell, on the other hand, was to *blow up* whatever it fell upon. It might occasionally, by the intense heat generated by the explosion,[1] set fire to its surroundings when inflammable; but this was a mere incidental consequence of its action. Its aim and end was to explode.

When a musket or cannon was fired there was a bright flash, a loud, momentary report, and a large volume of smoke.[2] When an incendiary missile was discharged from a machine there was no flash, but little smoke, and the only sounds were the whizzing and sputtering of the burning mixture and the creaking and groaning of bolts, spars, ropes, &c. :—

"With grisly soune out goth the greté gonne." [3]

An explosive missile made its way through the air with little noise[4] and less light:[5] during its flight

[1] Estimated for gunpowder at 3373° C.

[2] ". . . to be the mark
Of smoky muskets."
—*All's Well that Ends Well*, iii. 2.

[3] Chaucer's "Legend of Good Women," 637. Professor Skeat points out that the word "gonne" applies to the projectile in this line.

[4] Only the whirring of the shot.

[5] Only the faint light of the time fuze.

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the blazing contents of the incendiary shell doubtless gave out much light and made a considerable noise, as described by many early writers. When an explosive shell reached its object there was, sooner or later (if it acted at all), an explosion, occasionally followed by a conflagration: an incendiary shell produced a conflagration only.

The second difficulty arises from the change of meaning which many technical words have undergone in the lapse of years.

The Arabic word *barúd* originally meant *hail*, was afterwards applied to *saltpetre*, and finally came to signify *gunpowder*. Our own word *powder*, which at first meant a fine, floury dust (*pulvis*), is often used in the present day to designate the stringy nitrocelluloid, *cordite*—smokeless powder. The Chinese word *yo* means *gunpowder* now, although its first meaning was a *drug* or *plant*. For centuries gunpowder was called *kraut* in Germany, and to this day it is called *kruid* in Holland. The Danish *krud* has not long become obsolete.

The present Chinese word for *firearm*, *huo p'áu*, originally meant a *machine* for throwing blazing incendiary matter. The Arabic word *bundúq* at first meant a *hazel-nut*, secondly a *clay-pellet* the size of a hazel-nut, thirdly a *bullet*, and finally a *firearm*.[1] The Latin *nochus*, a *hazel-nut*, is used, strange to say, to designate a *smoke-ball* by an old German military writer, Konrad Kyeser, whose

[1] Sacy's *Chrestomathie Arabe*, Paris, 1827, iii. 68.

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"Bellifortis" dates from 1405.[1] The word was also applied in Germany to bullets in general, and more particularly to projectiles discharged by machines.

The word *Artillery*, both in France and England, originally meant *bows and arrows*. In his original account of the battle of Cressy, Froissart calls the apparatus and bolts of the Genoese crossbowmen *leur artillerie;* while a few lines further on he speaks of the *kanons* of the English.[2] Ascham, writing in 1571, says: "Artillerie nowadays is taken for two things: gunnes and bowes."[3] Selden reminds us that *gonne*, our present *gun*, at first meant a *machine* of the ballista type.[4] It is used in this sense in "Kyng Alisaunder," 3268, written A.D. 1275–1300, and other metrical romances. Like the Arabic *bundúq*, the word is occasionally applied to the *projectile*, as in the "Avowing of Arthur," st. 65. It is used in the modern sense, as *cannon*, in the "Vision of Piers the Plowman," Passus xxi, C text, 293, a poem begun in 1362 and finally revised by its author in 1390; and in all three meanings by Chaucer, in poems written

[1] Cod. MS. phil. 63, in the library of the University of Göttingen, quoted by Romocki, i. 134.

[2] Froissart's original account of the battle of Cressy in the Amiens MS. will be found in Kervyn de Lettenhove's ed. of the "Chronicles," Brussels, 1870, and in the Appendix to Polain's ed. of the *Vrayes Chroniques de Messire Jehan le Bel*, Brussels, 1863. See also "Cannon at Cressy," by the present writer, in *Proc. R. A. Inst.*, vol. xxvi.

[3] "Toxophilus," p. 67.

[4] "Sometimes we put a new signification to an old word, as when we call a Piece a Gun. The word Gun was in use in England for an Engine to cast a thing from a Man, long before there was any Gunpowder found out."—"Table Talk," p. 107.

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during the last quarter of the fourteenth century;—as a machine in the "Romaunt of the Rose," 4176, as a projectile in the "Legende of Good Women," 637, and as a cannon in the "Hous of Fame," 533.

"When the thing is perceived, the idea conceived," says Professor Whitney, "(men) find in the existing resources of speech the means of its expression—a name which formerly belonged to something else in some way akin to it; a combination of words," &c.[1] For example, a word, W, which has always been the name of a thing, M, is applied to some new thing, N, which has been devised for the same use as M and answers the purpose better.[2] W thus represents both M and N for an indefinite time,[3] until M eventually drops into disuse and W comes to mean N and N only. The confusion necessarily arising from the equivocal meaning of W during this indefinite period, is entirely due, of course, to neglect of Horace's advice to coin new names for new things.[4] Had a new name been given to N from the first, no difficulty could possibly have ensued, and our way would have been straight and clear. But as matters have fallen out, not only have we to determine whether W means M or N,

[1] "Language and the Study of Language," 1867, p. 126.

[2] *Cordite*, for instance, is frequently miscalled "smokeless *powder*."

[3] As *Artillery* for ages represented both *bows* and *cannon*.

[4] "Si forte necesse est
Indiciis monstrare recentibus abdita rerum,
Fingere cinctutis non exaudita Cethegis
Continget, dabiturque licentia sumpta pudenter."—A. P. 48.

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whenever it is used during the transition period,[1] but we have to meet the arguments of those, never far off, who insist that because W meant N *finally*, it must have meant N at some bygone time when history and probability alike show that it meant M and M only. Examples, enough and to spare, of such arguments will be met with shortly.

In consequence of the change of meaning which many military words have suffered, no translation of passages in foreign books containing ambiguous words should be relied upon, if access to the originals, or faithful copies of them, can be obtained. As an example of the necessity for this precaution, let us compare a few sentences relating to the siege of Jerusalem, A.D. 70, from the "Polychronicon" of Higden (*d.* cir. 1363), Rolls Series, iv. 429 *ff.*, with the translations of them by Trevisa, 1385, and by the author of MS. Harl. No. 2261, of A.D. 1432–50.

A

(1) Inde Vespasianus ictu arietis murum conturbat (Higden).

(2) Thanne Vaspacianus destourbed the wal with the stroke of an engyne (Trevisa).

(3) Wherefore Vespasian troublede the walle soore with gunnes and other engynes (MS. Harl.).

B

(1) Josephus tamen ardenti oleo superjecto omnia machinamenta exussit (Higden).

[1] *e.g.*, whether Artillery means bows and arrows or cannon in 1 Sam. xx. 40; but this is an exceedingly simple case.

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(2) But Joseph threwe out brennynge oyle uppon alle her gynnes and smoot all her gynnes (Trevisa).

(3) Then Josephus destroyede alle theire instruments in castenge brennenge oyle on hit (MS. Harl.).

C

(1) Quo viso tanta vis telorum ex parte Titi proruit, ut unius de sociis Josephi occipitium lapide percussum ultra tertium stadium excuteretur (Higden).

(2) Whan that was i-seie there fil so gret strenthe of castynge and of schot of Titus his side, that the noble knyght of oon of Josephus his felowes was i-smyte of that place with a stoon and flewe over the thrydde forlong (Trevisa).

(3) Titus perceyvenge that, sende furthe a sawte and schotte gunnes to the walles in so much that the hynder parte of the hedde of a man stondenge by Josephus was smyten by the space of thre forlonges (MS. Harl.).

D

(1) Admotis tandem arietibus ad templum (Higden).

(2) At the laste the engynes were remeved toward the temple (Trevisa).

(3) Titus causede his gunners to schote at the Temple (MS. Harl.).

No suspicion rests upon either of these translators; yet, were the original lost, a covert allusion

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to cannon might be discovered in Trevisa's translation of B and C, and the Harleian translation of A, C, and D would be put forward as proof positive of their use.

III

The claims of the Greeks to the invention of gunpowder are examined in Chap. III. Chap. IV. is an inquiry into the nature and authorship of the *Liber Ignium* of Marcus Græcus. The claims of the Arabs, Hindus, Chinese, and English are considered in Chaps. V.–VIII. In Part II. the progress of Ammunition is very briefly traced from the introduction of cannon to the introduction of breechloading arms.

As the book is addressed to the officers of the Army, who seldom have a library at command, the authorities for the statements of important facts are generally given at length. On all controversial points, when a foreign authority is quoted the original[1] is given as well as the translation. I have endeavoured to acknowledge my obligation in all cases where quotations have been borrowed from others without verification.

The invention of gunpowder was impossible until the properties of saltpetre had become known. We proceed, therefore, in the following chapter to determine the approximate date of the discovery of this salt.

[1] Except one disputed Sanskrit text which will be found in Rāy's "Hindu Chemistry," pp. 97–8.

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CHAPTER II

SALTPETRE

THE attention of the ancients was naturally attracted by the efflorescences which form on certain stones, on walls, and in caves and cellars; and the Hindus and nomad Arabs must have noticed the deflagration of at least one of them when a fire was lit on it. These efflorescences consist of various salts,—sulphate and carbonate of soda, chloride of sodium, saltpetre, &c.—but they are so similar in appearance and taste, the only two criteria known in primitive times,[1] that early observers succeeded in discriminating only one of them, common salt, from the rest. So close, in fact, is the resemblance between potash and soda, that their radical difference was only finally established by Du Hamel in 1736. Common salt received a distinctive name in remote times; all other salts were grouped together under such vague generic names as *nitrum*, *natron*, *afronitron*, &c.

No trace of saltpetre has hitherto been found

[1] "Les terres d'où l'on tire le kien, ou la couperose de Chine, fermentent comme celles du salpêtre; on y est souvent trompé, ce n'est qu'au goût qu'on peut distinguer les unes des autres."—Père Incarville, a Chinese missionary, in Reinaud and Favé, p. 251.

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anywhere before the thirteenth century. The Greek alchemists of preceding centuries are silent. There is no saltpetre in the earliest recipe we possess for Greek fire, No. 26 of the *Liber Ignium*,[1] ascribed to one Marcus Græcus, either as given in the Paris MSS. of 1300, or in the Munich MS. of 1438. It is true that the phrase *sal coctus* in this recipe has been translated by *saltpetre* in M. Hœfer's untrustworthy *Histoire de la Chimie*, but as MM. Reinaud and Favé remark: "Rien n'autorise à traduire ainsi; le sel ordinaire a été souvent employé dans les artifices."[2] There is no instance in Latin, I believe, of saltpetre being designated otherwise than by *sal petræ* (or *petrosus*), or by *nitrum*, singly or in combination with some other word, as *spuma nitri*. The substitution of *sal petræ* for *sal coctus*, in later editions of the recipe, only shows that when the valuable properties of saltpetre became known it was employed instead of common salt. The very fact of the change having been made by most of the later alchemists, proves that to them *sal coctus* did not mean *sal petræ*, but something else. If *sal coctus* had meant *sal petræ*, what need was there for the change? This change, however, was not universal. In the version of recipe 26, given in the *Livre de Canonnerie et Artifice de Feu*, published in Paris in 1561, but written long before by a fireworker well acquainted with saltpetre, we find: "prenez soufre vif, tarte, farcocoly (sarcocolla),

[1] Supposed to be of Greek origin.
[2] *Journal Asiatique*, Oct. 1849, p. 283.

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peghel (pitch), sarcosti (sal coctum), &c."[1] The word *coquo* (to boil or evaporate) was necessarily connected with the preparation of common salt by evaporation,[2] and *coctus* would correctly distinguish evaporated or artificial salt from natural or rock salt. In his "Natural History," xxxi. 39 (7), Pliny tells us that salt is found round the edges of certain lakes in Sicily which are partially dried up in summer by the heat of the sun; while in Phrygia, where much greater evaporation takes place (*ubi largius coquitur*), a lake is dried up (and salt is deposited) to its very middle. *Sal coctus* was salt recovered from salt water by natural or artificial heat, as distinguished from natural, or rock salt, which was dug out of the ground.[3]

The Arab alchemists before the thirteenth century are as silent as the Greeks: nothing that can be identified with saltpetre is to be found in their voluminous works. The evidence of Geber, so often cited to prove that saltpetre was known to the Arabs in the ninth century, has been stripped of all authority by M. Berthelot, who has satisfactorily proved that there were two Gebers. The real Arab, Jabir, says nothing of saltpetre, but he mentions a

[1] Reinaud and Favé, p. 142. On the next page, 143, *sarcosti* is spelled (by the same writer) *salcosti*.

[2] "Tunc aquam illam (salt water) coque in vase vitreo."—Albert Groot in Zetzner's *Theatrum Chemicum*, 1613, ii. 433.

[3] The Greeks had a corresponding distinction between natural and artificial salt. Herodotus calls the salt crystallised by the sun at the mouth of the Borysthenes ἅλες αὐτόματοι, automatic, or spontaneous salt, as distinguished from ἅλες ὀρυκτός, dug-out, or rock salt; iv. 53 and 185.

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salve used by naphtha-throwers[1] as a safeguard against burns. The other Geber, or psuedo-Jabir, was acquainted with saltpetre, as well he might be; for he was a western who lived some time about the year 1300,[2] and wrote a number of Latin works falsely purporting to be translations from the Arabic of the real Jabir. All doubt about the matter has been removed by M. Berthelot's publication of the real Jabir's Arabic writings.[3] It has been also suspected that the *sal Indicus* of the *Liber Sacerdotum*, *cir.* tenth century,[4] a salt again mentioned in the *Liber Secretorum* of Bubacar, *cir.* 1000,[5] means saltpetre. Both these works are translations from the Arabic or Persian,[6] and *sal Indicus* is the literal translation of the Persian—نمك هندى (nimaki Hindi) = نمك سياه (nimaki siyah) = salt of bitumen; a substance of the same family as the "salt of naphtha" also mentioned by Bubacar.

There is no word for saltpetre in classical San-

[1] Berthelot, iii. 153.

[2] Ib., i. 239. The forgeries in question may have been the work of several writers, but this does not affect the date given above.

[3] The Arabic works of the real Jabir are given by Berthelot in iii. 126 *ff.*; the Latin works of the false Jabir (or Geber) in i. 336 *ff.*

[4] Ib., i. 199, recipe 60.

[5] Ib., i. 308.

[6] Owing to the great number of Arabic words borrowed by the Persians it is extremely difficult to judge from a translation whether a lost original was Arabic or Persian, the more so as the Arabs borrowed largely from the Persian. Far more honour for scientific work has been paid to the Arabs, far less to the Persians, Syrians, and Hindus, than was their proper due. Renan says that Al-Kindi was the only Moslem philosopher of pure Arab blood.—*Discours et Conférences*, p. 391.

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skrit, *sauverchala* being a generic term for natural salts, which corresponded to, and was as comprehensive as the *nitrum*, *spuma nitri*, &c., of the West. "Recent Sanskrit formulæ for the preparation of mineral acids containing nitre, mention this salt under the name of *soraka*. This word, however, is not met with in any Sanskrit dictionary, and is evidently Sanskritised from the vernacular *sora*, a term of foreign origin."[1] Both Professor H. H. Wilson and Professor M. Williams, in their Sanskrit dictionaries, "erroneously render *yavakshara* as saltpetre, as also does Colebrooke in his 'Amarakosha.'"[2] The word means impure carbonate of potash obtained by the incineration of barley straw.[3]

At length, however, notwithstanding coarse scales and clumsy apparatus, the want of all means of registering time and temperature, and the absence of any general principle to guide them in their researches, the alchemists succeeded in differentiating certain natural salts from the rest, and among them saltpetre. The Chinese were acquainted with it about the middle of the thirteenth century.[4] Abd Allah ibn al-Baythar, who died at Damascus in 1248, tells us that *the flower of the stone of Assos*

[1] Udoy Chand Dutt, "Materia Medica of the Hindus," pp. 89-90. I presume that *sora* (being of foreign origin) was a corruption of the Persian شورة (*shora*) = saltpetre.

[2] "Hindu Chemistry," by Praphulla Chandra Rāy, Professor of Chemistry, Presidency College, Calcutta, 1902, pp. 99-100.

[3] Yavakshara was apparently the "barley" used in a saltpetre mixture of the Arabic treatise (in Syriac characters) given by Berthelot, ii. 198.

[4] Romocki, i. 51.

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was called *Chinese snow* by the Egyptian physicians and *barūd* (*i.e.* saltpetre) by the (Arab) people of the West.[1] Friar Bacon, whose *De Secretis* was written before 1249, and Hassan er-Rammah who wrote 1275–95, were thoroughly acquainted with the salt. A grand chemical discovery had been made, and saltpetre became known from China to Spain.

The Egyptians thought fit to call saltpetre "Chinese snow," but this does not justify the conclusion that the discovery was made by the Chinese. Consider our own phrases "Jerusalem" artichoke, "Welsh" onion, and "Turkey" cock. Jerusalem is a gardener's corruption of *girasole*, the Turkey came from America, and the home of the Welsh onion is Siberia. The Persians called their native alkaline salt *jamadi Chini*, and no one will suggest that this substance came from China.

It is evident from the way in which it is mentioned by the alchemists of the thirteenth century, and from their primitive methods of refining it, that saltpetre was then in its infancy. Roger Bacon speaks of it as one would speak of a substance recently discovered and still little known — "that

[1] هو زهر حجر اسيوس . . . هو ثلج الصين عند القدمآء من اطباء مصر ويعرفونه عامة المغرب والطباوها بالبارود .

Reinaud and Favé, p. 14. The phrase, "flower of the stone of Assos," was a thousand years old when Abd Allah used it, for we find it in Lucian's *Tragodopodagra* (*ἄνθος Ἀσίου λίθου*, *l.* 162), a work written A.D. 180–200. But, like so many other words, it completely changed its meaning in the lapse of years. Abd Allah used it to designate saltpetre: Pliny the elder ("Nat. Hist.," xxxvi. 17) tells us it had the property of utterly consuming dead bodies, except the teeth, in forty days—a property saltpetre does not possess.

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salt which is called saltpetre" (*illius salis qui sal petræ vocatur*).[1] Marcus Græcus thought it necessary to explain what the word means, in his 14th recipe which probably belongs to the latter years of the thirteenth century.[2] The methods of refining the salt given by Marcus and Hassan leave no possible doubt that in their time it had but just come into use. It is true that Bacon's method was much superior, if the solution of his steganogram given in Chap. viii. be accepted. But it would have been past all explanation had the method of the greatest natural philosopher of the age been found to be no better than that of an Arabic druggist or a European fireworker.

As the matter is one of the greatest importance, the methods of all three are given in full, together with that of Whitehorne, 1560. The Waltham Abbey method is added, as a standard by which to judge them. To admit of easy comparison, the corresponding operations are marked with the same letter. The five methods are summed up in Table I.

Waltham Abbey, 1860.

A. *Preparation of grough from natural saltpetre.*[3]

Natural saltpetre is dissolved in boiling water, the insoluble impurities removed, and the solution

[1] *Majus Opus*, London, 1733, p. 474.

[2] See chapter iv.

[3] This process was carried out in the East, or wherever the natural saltpetre was collected; not at Waltham Abbey. The facts are taken from the "Handbook of the Manufacture of Gunpowder," by Capt. F. M. Smith, R.A., London, 1871.

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evaporated by the sun or artificial heat. The solid residue is grough saltpetre, and contains 1 to 10 per cent. of impurities, consisting of the chlorides of potassium and sodium, sulphates of potash, soda, and calcium, vegetable matter, sand, and moisture.

B. *Boiling the solution of grough saltpetre.*

The grough saltpetre is placed in an open copper with a false bottom; water is added, and heat applied until the mixture boils at 110° C.

C. *Removal of the insoluble impurities.*

The scum which rises to the surface during this operation is removed by ladles; the sand and heavy impurities fall upon the false bottom, which is removed just before the mixture boils. The boiling is continued until the scum ceases to rise.

D. *Second boiling of the solution.*

Cold water is added; the solution is boiled for a few minutes, and then allowed to cool somewhat.

E. *Filtration.*

At 104.5° C. the mother liquid is transferred to a tank with holes in its bottom, closed by filters.

F. *Use of wood-ash, charcoal, &c.*

If the impurities prevent the liquid from passing freely through the filters, it is treated with glue,

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wood-ash, or, better, with a little animal charcoal, which seizes on the impurities and rises to the top as scum.

G. *Crystallisation.*

The mother liquid filters into the crystallising trough at 70.2° to 65.8° C.

H. *Stirring the depositing solution.*

The solution is kept in constant agitation by poles whilst cooling, in order that it may deposit in minute crystals, called *saltpetre flour*. Large crystals contain more or less of the impure mother liquid.

I. *Washing and drying.*

The agitation is discontinued at 25.8° C. and the mother liquid drawn off. The flour is drained on an inclined plane, transferred to a washing vat, where it is washed three times with cold water, and then finally dried.

WHITEHORNE, 1560.

A. *Preparation of grough from natural saltpetre.*

On the bottom of a vessel pierced with "three or fower littell holes" is placed a linen cloth, "or else the end of a broom, or some straw." A layer of nitrified earth, "a spanne thicknesse," is laid on

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this, and on the earth "three fingers' thicknesse" of a mixture of "two parts of unslacked lime and three of oke asshes, or other asshes. . . . And so, putting one rewe" of saltpetre alternately with one of the mixture, "you shall fill the tubbe . . . within a spanne of (its mouth), and the rest you will fill with water." The water, on percolating through the mass, drips into a brass cauldron which, when two-thirds full, is boiled "till it come to one-third part or thereabouts. And after take it off and put it to settell in a great vessell," when it is to be "clarified and from earthe and grosse matter diligentlie purged."

B. *Boiling the solution of grough saltpetre.*

The solution is then "taken and boyled of new."

F. *Use of wood-ash, animal charcoal, &c.*

When the solution boils and throws up scum, it is treated with a mixture of "3 parts of oke asshes and 1 of lime, together with 4 lbs. of rock alum to every 100 lbs. of the mother liquid." "In a little time you shall see it alaie, both clear and fair and of an azure colour."

C. *Removal of insoluble impurities.*

The heavy impurities, which sink to the bottom, are got rid of by pouring the clarified mother liquid into another vessel.

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G. *Crystallisation.*

"Take it out and put it in vessels of woode or of earth that are rough within, with certain sticks of wood, to congeal."

I. *Washing and drying.*

"This same saltpeter being taken from the sides of the vessel where it congealed, and in the water thereof washed, you must lay it upon a table to drie throughly."

F'.[1] *Use of wood-ash, animal charcoal, &c.*

"Minding to have (saltpetre) above the common use, for some purpose, more purified, &c. (which for to make exceeding fine powder, or aqua fortis, is most requisite so to be):—take of the aforesaid mixture (F) . . . and for every barrel of water you have put in the cauldron . . . you must put into it five potfulls" of the mixture. "In the same quantity of water so prepared, put so much saltpeter as it will dissolve."

D. *Second boiling of the solution.*

Boil the whole until it "resolve very well."

E. *Filtration.*

When the scum rises, transfer the mother liquid to a tub with holes in the bottom, on which is laid

[1] F', &c., means a repetition of F, &c.

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a linen cloth covered with a layer of sand four finger-breadths deep.

D′. *Third boiling of the solution.*

The filtered liquid is boiled again "in order to make the greater part of the water seeth away. . . . Make it boil so much until you see it ready to thicken, pouring in now and then a little of the mixture" (F).

G′. *Final crystallisation.*

The mother liquid is then transferred to wooden troughs "to congeal," for which three or four days are allowed. "After this sort thou shalt make the saltpeter most white and fair, and much better than at the first setting."

"Liber Ignium," *cir.* 1300.

A. *Preparation of grough from natural saltpetre.*

If natural saltpetre is dissolved in boiling water, cleansed, and passed through a filter, and boiled for a day and a night; the (grough) saltpetre will be found deposited in crystals at the bottom of the vessel.

The original is as follows:—

"Nota, quod sal petrosum est minera terræ et reperitur in scrophulis contra lapides. Hæc terra dissolvitur in aqua bulliente, postea depurata et distillata per filtrum. et permittatur per diem et noctem

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integram decoqui, et invenies in fundo laminas salis conielatas cristallinas."[1]

Hassan er-Rammah, 1275–95.

A. *Preparation of grough from natural saltpetre.*

"Take white, clean, bright (natural) saltpetre *ad lib.*, and two new (earthen) jars. Put the saltpetre into one of them, and add some water. Put the jar on a gentle fire until it gets warm" (and the saltpetre dissolves. Skim off) "the scum that rises" (and) "throw it away. Stir up the fire until the liquid becomes quite clear. Then pour it into the other jar in such a way that no scum remains attached to it. Place this jar on a low fire until the contents begin to coagulate. Then take it off the fire, and beat (the crystals) gently."

F. *Use of wood-ash, animal charcoal, &c.*

"Take dry willow wood, burn it, and plunge it into water according to the recipe for its incineration. Take three parts by weight of the saltpetre" (just obtained), "and the third of a part of the wood-ash, which has been carefully pulverised, and put the mixture into a jar—if made of brass, so much the better."

B. *Boiling the solution of grough saltpetre.*

"Add water and apply heat, until the ashes and saltpetre no longer adhere together. Beware of sparks."

[1] See chapter iv., recipe 14.

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The original is as follows :—

باب

صفة حل البارود[1]

يوخذ البارود الابيض النقى النارى مهما اردت وتاخذ طاجنين جدد ويحط فى الطاجن الواحد ويغمر بالمآء ويوقد عليه نار لينة حتى يفتر وتطلع رغوته فارمها واوقد تحته جيدا حتى يروق ماؤه الى غاية ويقلب المآء الرايق فى طاجن اخر بحيث لا يتراك من التفل شى ويوخذ عليه وقدا لطيفا الى ان يجمد وتشيله وتصفيه ناعما ويوخذ الحطب الصفصاف اليابس يحرق ويغمر على صفة العراق ويزن من البارود الثلثين والثلث من رماد الفحم الذى صفيته بالميزان ويعاد الى الطاجنين وان كانت الاعادة فى طاجن نحاس فهو اجود ويعمل عليه قليل مآء وتحصه بحيث ان لا يلتزق واحذر من هرر النار.

ROGER BACON, *cir.* 1248.

A. *Preparation of grough from natural saltpetre.*

Carefully wash the natural saltpetre, and (as far as possible) remove all impurities. Dissolve it in water over a gentle fire, and boil it until the scum ceases to rise, and it is purified and clarified. Let the operation be repeated again and again, until the solution is clear and bright. Let it then deposit its crystals of the stone which is not a stone,[2] and dry them in a warm place.

[1] Taken from Reinaud and Favé, p. 237.

[2] *i.e.* the lapis assius = saltpetre.

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B. *Boiling the solution of grough saltpetre.*

Pulverise the crystals of grough saltpetre thus obtained, and immerse them in water. Make a powder of two purifying substances in the proportion of 3 : 2. Dissolve the crystals over a gentle fire.

F. *Use of wood-ash, charcoal, &c.*

To the powder add some animal charcoal, and thoroughly incorporate the ingredients (in a vessel). Then pour the hot solution upon it, and your object (of clarifying the mother liquid) will be gained.

C. *Removal of the insoluble impurities.*

If (by its appearance and taste you judge that) the solution is good, pour it out (into a crystallising vessel, leaving the heavy impurities behind).

G. *Crystallisation.*

(The mother liquid is now allowed to crystallise.)

H. *Stirring the depositing solution.*

(While depositing), stir the solution with a pestle. Collect the crystals as best you can, and gradually draw off the mother liquid.

The original is as follows :—

Calcem diligenter purifica, ut fiat terra pura penitus liberata ab aliis elementis. Dissolvatur in aqua cum igne levi, ut decoquatur quatenus separetur pinguedo sua, donec purgatur et dealbetur. Iteretur distillatio donec rectificetur : rectificationis novis-

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sima signa sunt candor et crystallina serenitas. Ex hac aqua materia congelatur. Lapis vero Aristotelis, qui non est lapis, ponitur in pyramide in loco calido.

Accipe lapidem et calcina ipsum. In fine parum commisce de aqua dulci; et medicinam laxativam compone de duabus rebus quarum proportio melior est in sesquialtera proportione. Resolve ad ignem et mollius calefac. Mixto ex Phœnice adjunge, et incorpora per fortem motum; cui si liquor calidus adhibeatur, habebis propositum ultimum. Evacuato quod bonum est. Regyra cum pistillo, et congrega materiam ut potes, et aquam separa paulatim.[1]

TABLE I.

Methods of Refining Saltpetre.

Roger Bacon, *cir.* 1248	A	B	F	C	G	H	...	...	...	...	...
Hassan er-Rammah, 1275-95 . . .	A	F	B	...	...	...	...	...	...	...	...
Liber Ignium, *cir.* 1300	A	...	...	...	...	...	...	...	...	...	...
Whitehorne, 1560 .	A	B	F	C	G	I	F′	D	E	D′	G′
Waltham Abbey, 1860 .	A	B	C	D	E	F	G	H	I	...	...

A = Preparation of grough from natural saltpetre.
B = Boiling the solution of grough saltpetre.
C = Removal of insoluble impurities.
D = Second boiling of the solution.
E = Filtration.
F = Use of wood-ash, animal charcoal, &c.
G = Crystallisation.
H = Stirring the depositing solution.
I = Washing and drying.

[1] The way in which this process has been obtained will be explained in chapter viii. The phrases within brackets there are simply written consecutively here, word for word, except a few conjunctions rendered unnecessary by the punctuation.

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The simple and highly probable conclusion to be drawn from the foregoing facts is, that saltpetre was not discovered until the second quarter of the thirteenth century; but this conclusion is not universally accepted. It is said by some that although saltpetre was unknown to the rest of the world until then, it had been secretly used by the Greeks for five hundred years. This theory will be examined in the following chapter.

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CHAPTER III

THE GREEKS

HOMER knew nothing apparently of incendiary compositions. When the Trojans set fire to the Greek ships, he certainly says that they burned with "unquenchable flame" (ἀσβέστη φλόξ), *Iliad*, xvi. 123; but this is a mere figure of speech, for presently afterwards he tells us that Patroclus extinguished the fire (κατὰ δ' ἔσβεσεν αἰθόμενον πῦρ), 293.

The Assyrian bas-reliefs in the British Museum prove that liquid fire was used in warfare in very remote times. Whether the Greeks adopted its use from the Orientals or originated it themselves, there is little evidence to show; but traces of it are found at an early date, for instance at the siege of Syracuse,[1] 413 B.C., and the siege of Rhodes,[2] 304 B.C. Vessels full of burning matter were thrown, at first by hand, from walls and the tops of forts upon besiegers; and when shell of suitable construction had been devised, these missiles were discharged from machines.

The earliest instance of the use of firearms by the Greeks is found in Thucydides, ii. 75, where it is stated that at the siege of Platæa, 429 B.C., the

[1] Thucydides, vii. 43. [2] Diodorus Siculus, xx. 88.

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Platæans found it necessary to protect a wooden wall by skins and hides against the fire-arrows (πυρφόροις ὀϊστοῖς) of their Peloponnesian besiegers. By the time of the Roman Empire, fire-arrows were so well known as to be mentioned by the Latin poets,[1] and the historians speak of fire-lances which were discharged from machines[2] (*adactæ tormentis ardentes hastæ*). Vegetius, who lived in the fourth century A.D., gives the composition of fire-arrows;[3] and Ammianus Marcellinus, who lived about the same time, points out their defects. First, the fire-arrow had to be discharged with a low velocity—*ictu enim rapidiore extinguitur;* it was extinguished by the cooling effect of the air when discharged with the full force of the bow. Secondly, in addition to its low velocity (and consequently limited range) it was extinguished when covered with clay.[4] However, the composition was easy to light and hard to put out—even with clay or vinegar; its viscosity enabled it to stick to the body it struck; and, becoming more and more fluid from the heat of combustion, it "spread like wild-fire."

But the use of incendiaries was not confined to grenades and arrows. At the siege of Platæa, just referred to, the Spartans piled up faggots of brush-wood against the walls, and, after pouring a mixture of sulphur and pitch on the heap, set fire to it in

[1] Vergil, *Æn.*, ix. 705; Lucan, *Phars.*, vi. 199.
[2] Tacitus, *Hist.*, iv. 23.
[3] *De Re Militari*, chap. viii. See Table II.
[4] xxiii. 4.

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order to burn the town.[1] They would have gained their object but for a rainstorm which put out the fire. We have here perhaps the earliest historical account of the composition of an incendiary—429 B.C. At the siege of Delium, 424 B.C., a tree was cut down and hollowed out, so as to form a tube, and from one end of it, which was protected by a covering of iron, was hung a cauldron containing a burning mixture of charcoal, sulphur, and pitch. Into this cauldron was introduced an iron bellows-pipe, leading from the end of the tree from which it hung. Having transported the machine close to the wall of the town (the cauldron to the front), the besiegers inserted the snout of a large bellows into the other end of the hollowed tree, and blew them. A great flame was thus produced; the wall, in which there was much wood, was set on fire; the heat of the fire and the vapour of the incendiary drove the defenders from the walls, and the town fell.[2] Its simplicity shows that the mixture belongs to the infancy of incendiaries in Greece.

We meet with fire-ships as early as 413 B.C., when the Syracusians employed one ineffectually against the Athenian fleet;[3] and a special incendiary for naval use is recommended by Æneas, the tactician, about 350 B.C. It consisted of sulphur, pitch, incense, pine-wood, and tow. The mixture was stowed

[1] Thucydides, ii. 77.

> "E lor porge di zolfo e di bitumi
> Due palle, e'n cavo rame ascosi lumi."
>
> —Tasso, *Ger. Lib.*, xii. 42.

[2] Ib., iv. 100.

[3] Ib., vii. 53.

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TABLE II.

Greek Fires.

Æneas.[1] *cir.* 350 B.C.	Vegetius.[2] *cir.* A.D. 350.	Liber Ignium.[3] 1200–1225.	Kyeser.[7] 1405.	Wild Fire.[8] 1560.	Carcass Composition.[9] 1903.
Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur
Pitch	Bitumen	Pitch	...	Pitch	Tallow
Pine-wood [10]	Rosin	Sarcocolla [4]	...	Charcoal	Rosin
Incense	Naphtha	Petroleum	Petroleum	Turpentine	Turpentine
Tow	...	Sal Coctus [5]	Salfanium ?	Bay Salt	Crude Antimony
...	...	Oil of Gemma	...	...	...
...	...	Tartarum [6]	Saltpetre	Saltpetre	Saltpetre

[1] *Poliorketikon*, xxxv. 79.
[2] *De Re Militari*, iv. 8.
[3] Recipe 26 (see Chap. iv.).
[4] A gum.
[5] Salt recovered from salt-water by natural or artificial heat.
[6] Cream of tartar = bitartrate of potash.
[7] "Bellifortis," in Romocki, i. 154.
[8] Whitehorne, Chap. xxix. fol. 40.
[9] Official "Treatise on Ammunition."
[10] *i.e.* Pine-wood charcoal.

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in egg-shaped, wooden vessels, admirably adapted for their purpose, which were thrown lighted upon the enemy's decks.[1]

In such ways were incendiaries employed by the Greeks for nearly eleven centuries after the siege of Platæa. During this long period the composition was of course improved, and the mixture of the seventh century A.D. burned more fiercely, and was harder to put out than that of the fourth century B.C.; but nevertheless the two mixtures were of the same species. At length, in the decade 670–80, a new species was devised. For the sake of clearness, the old incendiary mixtures will henceforward be called Greek fire; the new one "sea-fire."

We are told by Theophanes in his "Chronography," written 811–815, that in the year 673 an architect called Kallinikos[2] fled from Heliopolis in Syria to the Romans (*i.e.* Constantinople), and eventually compounded a "sea-fire" which enabled them to burn large numbers of the Moslem vessels engaged in the Seven Years' War,[3] 671–677. This incendiary was again employed with success against the Moslems during their second attack against Constantinople, 717, and at the decisive naval

[1] In *Bibliotheca Script. Græc. et Rom. Teubneriana.* Leipsig, 1874. Chap. xxxv. p. 79. See Table II.

[2] Kallinikos was probably a Syrian-Greek; Hertzberg, *Gesch. der Byzantiner*, &c., p. 58.

[3] Τότε Καλλίνικος ἀρχιτέκτων ἀπὸ Ἡλιουπόλεως Συρίας, προσφυγὼν τοῖς Ῥωμαίοις, πῦρ θαλάσσιον κατασκευάσας, τὰ τῶν Ἀράβων σκάφη ἐνέπρησεν καὶ σύμψυχα κατέκαυσεν. Καὶ οἱ Ῥωμαῖοι μετὰ νίκης ὑπέστρεψαν καὶ τὸ θαλάσσιον πῦρ ἔυρον. *Corp. Script. Hist. Byzant.*, ed. Niebuhr: "Theophanes," A.M. 6165, A.C. 665; i. 542.

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victory over the Russians under Igor in 941. The evidence of Theophanes about Kallinikos is corroborated almost verbally by the Emperor Constantine VII., Porphyrogenitus, in Chap. xlviii. of his "Administration of the Empire": "Be it known that under the reign of Constantine Pogonatus (668 685) one Kallinikos, who fled from Heliopolis to the Romans, prepared a 'wet-fire' to be discharged from siphons, by means of which the Romans burned the fleet of the Saracens at Cyzicus and gained the victory."[1] It is true that when writing to his son (in Chap. xiii. of the same work) the Emperor gives (or tells his son to give) a different version of the invention of sea-fire: "If any persons venture to inquire of you how this fire is prepared, withstand them and dismiss them with some such answer as this—that the secret was revealed by an angel to the first Emperor Constantine" (A.D. 323–337).[2] But this passage only proves that the Emperor was mendacious and his people superstitious. There can be little doubt that this great invention was made by a Greek for the Greeks in the decade 670–680; but what was the nature of the mixture? All we know for certain about it is that it was a State secret, was intended for sea service, burned with

[1] *Ἰστέον ὅτι ἐπὶ Κωνσταντίνου Πωγωνάτου . . . Καλλίνικός τις ἀπὸ Ἡλιουπόλεως, Ῥωμαίοις προσφυγών, τὸ διὰ τῶν σιφώνων ἐκφερόμενον πῦρ ὑγρὸν κατεσκεύασε, δι' οὗ καὶ τὸν τῶν Σαρακηνῶν στόλον ἐν Κυζίκῳ Ῥωμαῖοι καταφλέξαντες τὴν νίκην ἤραντο.*

[2] K. K. Müller, in his *Eine griechische Schrift über Seekrieg*, 1882, p. 44, pertinently remarks that Jähns, who accepts this early date, can give no example of the use of sea-fire before the seventh century.

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much noise and vapour, and was projected from siphons. In other words, the mixture fulfilled the following conditions :—

(1) Its composition could be kept secret.

(2) It had some close connection with the sea, or water.

(3) It burned with much noise and smoke.

(4) It had some close connection with siphons, or tubes.

The fact that the sea-fire was made a State secret proves that it did not belong to the same family as the Greek fire of Æneas and Vegetius which, in one form or another, had been known all over the East from time immemorial. It was a new mixture—*i.e.* either a mixture containing some substance not hitherto known, or a mixture of known substances not hitherto combined together for warlike purposes. Many hold that an unknown substance was employed, and, further, that it was no other than saltpetre. We might, of course, fall back on the conclusion established in Chap. ii., and reply that saltpetre was not discovered until the thirteenth century and could not have been used as an ingredient of an incendiary in the seventh century. But the conclusion drawn in Chap. ii. was not a certain one: it was there characterised as highly probable. Saltpetre might possibly have been employed, and a belief which is shared in by some good writers deserves respectful consideration. We have, therefore, to investigate how far a saltpetre mixture would satisfy the above four conditions.

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There was absolutely nothing to attract public attention in the purchase from time to time of common, well-known substances, such as sulphur, quicklime, naphtha, &c. &c., by the authorities of the Arsenal; but the suspicions of the spies and traitors, always to be found in Constantinople,[1] would have been instantly roused by the importation of any new or rare substance such as saltpetre. And whence could saltpetre have come? M. Berthelot recognises the importance of this question, although he cannot answer it: "Comment se procurait-on le salpêtre? . . . Aucun renseignment n'est venu nous l'apprendre. Ce point pourtant est capital."[2] Saltpetre would naturally have been obtained from the countries where it was most abundant and cheapest—from the East; but the Greeks could not have relied upon this source of supply, for whenever political complications arose between the Emperor and the Caliph—and they were interminable—the ports of Egypt and Syria were closed against Greek ships. However, saltpetre did not grow in the streets of Constantinople: the natural salt (if used) must have been collected *somewhere*, and sold to Government by *someone*, and transported *somehow* to the capital; and what despot could have tied the tongues of collectors, merchants, sailors, and porters? The mere facts that only one State trafficked in saltpetre, that this State only bought it in time of war,

[1] "Traitors are often to be suspected even about your person" (ὑποπτεύονται τινες προδόται καὶ παρά σοι πολλάκις ὄντες). Leo's "Tactics," xxi. 35.

[2] *Revue des Deux Mondes*, 15th Aug. 1891, p. 805.

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and that this State alone employed sea-fire, would have immediately betrayed the secret of its composition to these men, and what was known to them was known to the world. It is most improbable that the use of saltpetre could have been concealed for one year, much less the five hundred years during which the secret of the sea-fire was successfully guarded. I may be reminded of the Emperor Constantine VII.'s statement (in Chap. xiii. of his "Administration, &c."), that on one occasion a Roman general, corrupted by a large bribe, did reveal the secret and shortly afterwards, when entering a church, was consumed by fire which fell from heaven upon him. The story is obviously legendary. The venal general is as unreal as the fire from heaven; he is merely introduced to us as "an awful example," and we cannot endow him with reality by rejecting the fire. The claim of the Marquess Carabbas to reality is not established by denying the existence of Puss-in-Boots. Had the secret been divulged the sea-fire would have been used against the Greeks, and no mixture that can be identified with it ever was.

A saltpetre mixture, then, would not, in all probability, have fulfilled the first condition, nor would it have fulfilled the second. There is no conceivable connection between saltpetre and the sea, or water in general. A saltpetre mixture (of suitable proportions) would have proved a much better incendiary than Greek fire, but it would have acted as effectively from a fort as from a ship. Indeed, if we consider the ill effect of the moist sea air on the

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impure saltpetre of early times, we are justified in saying that the action of such mixtures on land would have been better, in general, than at sea.

A saltpetre mixture would have fulfilled the third condition by burning with much noise and smoke, which we may suppose to be the essential meaning of the Emperor Leo's phrase, "thunder and smoke."[1] We cannot reasonably attach greater significance to one of the commonest of all metaphors, thunder, which has been applied times unnumbered to the human voice, to the bursting of a child's cracker,[2] and to the whirring of a dart. "Never burst such peals from the thunder-cloud," says Vergil, as were produced by the javelin thrown by Æneas.[3]

As regards the fourth condition, the above statement of the Emperor Constantine about sea-fire and siphons[4] completely justifies us in concluding that there was some necessary connection between the two things. Now, there was no necessary connection between saltpetre mixtures, even when explosive, and siphons. Small quantities of such mixtures could have been, and eventually were, thrown by hand, in grenades, like Greek fire. Saltpetre mixtures, therefore, would not have fulfilled the fourth condition.

[1] Μετὰ βροντῆς καὶ καπνοῦ. "Tactics," xix. 51.

[2] By Friar Bacon. See Chapter viii.

[3] ". . . . . nec fulmine tanti
Dissultant crepitus . . . . ."—*Æn.*, xii. 922.

[4] Siphons, of whatever kind, were known before sea-fire. On hearing of the Moslem preparations to attack him in 671, Constantine Pogonatus ordered the siphon-bearing warships (δρόμωνας σιφωνοφόρους) to be put in commission.—Theophanes' "Chronography," i. 542.

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The result of the foregoing inquiry is, that a saltpetre mixture would have only fulfilled one, the third, of the four conditions to which the sea-fire was subject; and we have now to cast about for some mixture of known substances, not hitherto combined together for warlike purposes, which would have fulfilled them all.

A clue to the composition of the Kallinikos mixture may perhaps be found in its Greek name, "sea-fire" or "wet-fire." One substance had long been known with whose combustion water was closely connected — quicklime, and with its properties Kallinikos, as an architect, must have been perfectly familiar. Its temperature rises—to 150° C. (302° F.) if the quantity be large—when sprinkled with water, and it can consequently be employed to ignite substances with low points of ignition. For example, if a mixture of quicklime and naphtha be thrown into water, the rapid rise in temperature of the lime causes a sudden and strong development of vapour from the naphtha, which on mixing with the air becomes highly explosive. Such a mixture, it is almost unnecessary to add, could not be handled with safety *after* it has been wet. Plutarch was aware of the explosive nature of naphtha vapour. "Naphtha," he says, "is like bitumen, and is so easy to set on fire that, without touching it with any flame, it will catch light from the rays which are sent forth from a fire, burning the air which is between both."[1] Pliny speaks of the heat developed

[1] "Alexander," *c.* 35; tr. by Stewart and Long.

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by quicklime when sprinkled with water. "It is strange," he says, "that what has already been burnt should be ignited by water" (*mirum aliquid, postquam arserit, accendi aquis*).[1] The same property is implicitly referred to in the "Kestoi," attributed to Sextus Julius Africanus of Emaus, who lived under Alexander Severus, 222–235. The military portions of this work, however, must have been written long afterwards, in the end of the sixth or the beginning of the seventh century at the earliest; for Belisarius, who was born in 505, is mentioned in the sixty-sixth chapter.[2] In the forty-fifth chapter there is a recipe for a quicklime-asphalt composition, which is called "automatic fire." This mixture was used by jugglers to exhibit "spontaneous combustion," a little water being secretly poured on a plate on which a ball of the composition was placed.[3] It contained very little quicklime (*παντέλως ὀλίγον*). Cameniata tells us that at the storming of Salonika in 904 the Moslems threw "pitch and torches and quicklime" over the walls.[4] By "quicklime" he probably meant the earthenware hand grenades, filled with wet quicklime, described by the Emperor Leo, who then sat on the throne (886–911). "The vapour of the quicklime," he says, "when the pots are broken,

[1] "Natural History," xxxvi. 53.

[2] See Boivin's notes on the "Kestoi" in *Vet. Mathematicorum . . . Op.*, ed. Thévenot, 1693, p. 357; and Gelzer's *S. J. Africanus*, 1880, i. 13.

[3] In the *Deipnosophists* of Athenæus a juggler is represented as producing automatic fire, *c.* 16, *e.*

[4] Πίσσα καὶ δᾷδες καὶ ἄσβεστος. *Corp. Script. Hist. Byzant.*, Pt. xxii. p. 537.

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stifles and chokes the enemy and distracts his soldiers."[1]

The simplest and most probable explanation of the nature of the sea-fire then is, that it was a sulphur-quicklime-naphtha mixture of the same family as those shown in the following Table.

TABLE III.

Sea-Fires.

Liber Ignium.[2] *cir.* 1300.	Liber Ignium.[3] *cir.* 1350.	De Mirabilibus.[4] *cir.* 1350.	Kyeser.[5] 1405.	Hartlieb.[6] *cir.* 1425.
Sulphur.	Sulphur.	Sulphur.	Sulphur.	Sulphur (Oil of).
Quicklime.	Quicklime.	Quicklime.	Quicklime.	Quicklime.
Oil.	Turpentine.	Naphtha.	Petroleum.	Mastic.
Gum Arabic.	...	Wax.	Wax.	Gum Arabic.
...	...	Oil of Balm.	...	...

Such a mixture would have completely fulfilled the four conditions already mentioned. First, the

[1] Χύτρας τε ἀλλ' οὐκ ἀσβέστου πλήρης κ.τ.λ. "Tactics," xix., § 54, in *Meursii Op.*, vi.

[2] Recipe 24 (see Chapter iv.).

[3] Nürnberg MS., in Romocki, i. 125, recipe, "ignis qui in pluvia."

[4] Generally ascribed to Albert Groot, but much more probably by one of his pupils. Berthelot, i. 91.

[5] Romocki, i. 154.

[6] Ib., 130.

N.B.—None of these mixtures professes to be the official Greek sea-fire, the exact composition of which is unknown; but the "De Mirabilibus" mixture is probably a close approximation to it. Although called sea-fires here, they were not so called by their western authors, who were ignorant of the use and even of the name of sea-fire. The first four recipes are described as mixtures which will ignite "when rain falls upon them." Hartlieb alone foresaw that such mixtures would ignite "if thrown upon water."

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secret of its composition was easy to keep, since it lay in the choice and proportions of known ingredients; not in the use of one special and unknown substance (such as saltpetre), smuggled privily into the Arsenal[1] with a mystery which was certain to excite the curiosity of a people who "spent their time in nothing else, but either to tell or to hear some new thing." Secondly, it was literally a "sea-fire" or "wet-fire,"—a fire which was ignited by water and which burned on its surface. Thirdly, its combustion gave rise to a considerable volume of vapour and a series of small explosions in the air. Fourthly, from the mode of its combustion it was unsafe to handle after ignition, and it was necessarily discharged from siphons. This simple explanation of the sea-fire[2] sweeps away the insurmountable difficulties raised by the saltpetre theory. We have no longer to believe in the patriotic silence of Byzantine officials, workmen and sailors, maintained for five hundred years; we have no longer to admit reluctantly that saltpetre was known in Greece, where it occurs in comparatively scanty quantity, five hundred years before it was known in the great natural storehouse of this salt, Asia; we have no longer to suspect the whole body of Greek writers on alchemy and pharmacy, from the seventh to the thirteenth century, of having entered

[1] Cedrenus seems to convey that the manufacture of incendiaries was the privilege of the Lampros family, but it was presumably carried on in some Government establishment (ἐκ τούτου κατάγεται ἡ γενεὰ τοῦ Λαμπροῦ, τοῦ νυνὶ τὸ πῦρ ἐντέχνως κατασκευάζοντος); ed. Bekker, Bonn, 1838, i. 765.

[2] Herr von Romocki was, I believe, the first to offer this explanation.

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into a vast conspiracy of silence to hide their knowledge of saltpetre from the barbarians; we are no longer left wondering whence the Greeks got their saltpetre, and why they gave the name of "sea-fire" to a mixture in no way connected with the sea; and we are no longer perplexed by the fact that the earliest recipes for Greek fire contain no saltpetre.[1]

It remains to inquire how the sea-fire was expelled from the siphons.

There were two kinds of siphons, large siphons and hand-siphons.

Of the hand-siphons there were several patterns. Some seem to have been thrown by hand, like squibs;[2] from others, mentioned by Cameniata, the charge was projected by air[3]—presumably by a bellows or some such contrivance; while in a third kind, described by the Princess Anna, a pellet was blown by the breath through a flame placed before the front end of the tube.[4] The two latter siphons were of the same species, and as Anna's was charged with Greek fire[5] we may suppose Cameniata's took a similar charge.

The large sea-fire siphon was fixed in the bow of the ship and served by the two foremost rowers, one

[1] See p. 13, and Table II., col. *Liber Ignium.*

[2] Dr. Bury in Gibbon's "Decline and Fall," &c., vii. 540.

[3] Πῦρ τε διὰ τῶν σιφώνων τῷ ἀέρι φυσήσαντες, p. 536.

[4] Ἐμφυσᾶται . . . λάβρῳ καὶ συνεχεῖ πνεύματι κἀθ' ὄντως ὁμιλεῖ τῷ πρὸς ἄκραν πυρί. "Alex.," xiii. 3.

[5] "From the fir and such like evergreen trees may be prepared a fiercely-burning mixture" (ἀπο τῆς πεύκης καὶ ἄλλων τινῶν τοιούτων δένδρων ἀειθαλῶν συνάγεται δάκρυον ἔυκαυστον). Ib. See Æneas' mixture in Table II. Anna's recipe is intentionally incomplete.

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of whom laid the siphon and was called the siphonator, while the other, we may suppose, loaded it. The siphon was mounted on a swivel, as may be gathered from the account given by the Princess Anna of the naval battle fought near the island of Rhodes in 1103 by the Greeks and the Pisans. The latter were terrified, she says, by an apparatus which directed on them fire of an extraordinary nature. "Ordinary flame rises upwards, but this flame shot downwards and sideways as well, at the will of the gunner."[1] Unless the siphon was mounted on a swivel, the phrase which I have translated by "at the will of the gunner" (ἐφ' ἃ βούλεται ὁ πέμπων) would be meaningless.

In his *Recherche sur le Feu Grégeois*, p. 23, M. Chrétien-Lalanne maintains that the incendiary was expelled from the siphon by means of a spring. This theory is inadmissible, for helical springs are not heard of until long after the time in question. Further, the ancients possessed no means of condensing air to the degree necessary for the projection of a heavy body over even the short ranges of the Dark Ages, and steam power had hardly been recognised at all.[2] Therefore, it has been urged, the incendiary must have been expelled from the

[1] Οὐδὲ γὰρ ἐθάδες ἦσαν τοιούτων σκευῶν ἡ πυρὸς, ἄνω μὲν φύσει τὴν φορὰν ἔχοντος, πεμπομένου δ' ἐφ' ἃ βούλεται ὁ πέμπων κατά τε τὸ πρανὲς πολλάκις καὶ ἐφ' ἑκάτερα. "Alex.," *l.* xi., *c.* 10.

[2] The earliest notice of steam, as a motive power, is found in the *Pneumatica* of Heron of Alexandria, *cir.* 130 B.C. No further progress seems to have been made until the publication of the *Pneumatica* of Giambattista della Porta in 1601. Perkins' steam-gun was exhibited in 1824.

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siphon by means of an explosive saltpetre mixture, this being the only way of effecting the object that remained at the disposal of the ancients. As will be seen presently, there remained a simple and efficacious method, involving very little expense and no danger whatever; a fact which in itself would be sufficient to meet the above argument in favour of saltpetre, even were it unsupported by the evidence already brought forward in Chap. ii. to show that saltpetre had not been yet discovered at the time in question, and the evidence adduced in the present chapter to prove that in fact it was not used. Further, the supposition that an explosive was employed is excluded by the construction of the siphon, which was made of wood. Such is the only reasonable explanation that can be given of the Emperor Leo's order that the siphons should be "cased with bronze."[1] Had they been of metal, a casing of bronze would have been a useless complication; but, being of wood, an internal casing of metal was absolutely necessary to protect them from the flame of the burning composition. Only one round probably could have been fired from a wooden tube by means of an explosive, and that round in most cases would have been more fatal to the siphon detachment than to the enemy.

[1] Ἐχέτω δὲ πάντως τὸν σίφωνα κατὰ τὴν πρώραν ἔμπροσθεν χαλκῷ ἐμφιεσμένον. "Tactics," xix. § 6. There is no ambiguity about the word ἠμφιεσμένον, which is commonly applied to clothing, *e.g.* ἄνθρωπον ἐν μαλακοῖς ἱματίοις ἠμφιεσμένον = "a man clothed in soft raiment," Luke vii. 25. I mention this because it has been stated and restated that the siphons were *made* of bronze, instead of being "clothed" or "cased" with bronze.

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Again, as the projectile was simply a lump of oleaginous matter, it would have been blown by an explosive cartridge into thousands of fragments, each of them so small as to be worthless for incendiary purposes; for the efficacy of an incendiary depends to a great extent on its containing a large quantity of matter.

Since the use of springs, compressed air, and steam were impossible, and the use of an explosive extremely improbable, it only remains to examine the arguments for and against water as the motive power.

The Emperor Leo VI. speaks of the "artificial fire discharged by means of siphons;"[1] the Emperor Constantine VII. speaks similarly of "the wet-fire projected by means of siphons;"[2] and if we translate *siphon* by *tube* both phrases are intelligible, but neither gives any hint as to the means by which the mixture was expelled from the tubes. But like so many other military words, *siphon* has (at least) two meanings, and signifies not only a tube, but a *fire-engine*, or *water-engine*, or *squirt*. Heron of Alexandria (*cir.* 130 B.C.) begins his description of a fire-engine with the words: "The *siphons* used for the extinction of fire are made as follows."[3] Pliny the Younger (*cir.* 100 A.D.), in a letter to the Emperor Trajan about a fire which had taken place

[1] Ἐσκευασμένον πῦρ . . . διὰ τῶν σιφώνων πεμπομένον. Ib., § 51.

[2] See p. 34 *n.*

[3] Οἱ δὲ σίφωνες δι᾽ ὧν χρῶνται εἰς τοῖς ἐμπρησμοῖς κατασκευάζονται δυτως. "Spiritalia," in *Vet. Mathemat. Op.*, ed. Thévenot, p. 180.

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in the town of Nicomedia, observes that "there was not a *sipho*, nor even a bucket, at hand to quench it."[1] Hesychius in his Greek Lexicon, about the end of the fourth century, gives under σίφων: "an apparatus for pumping water in conflagrations."[2] If we translate *siphon* by *water-engine*, as we are perfectly justified in doing, we find that the phrases used by the two Emperors are not only intelligible, but indicate both the mode of projection and the mode of ignition of the sea-fire. The lump of quicklime-naphtha-sulphur was projected, and at the same time ignited, by applying the hose of a water-engine to the breech of the tube, which thus became an integral part of the apparatus to which it gave its name.

Two obscure passages in Byzantine works, which hitherto have never been satisfactorily explained, are made clear by this interpretation. The first occurs in the "Tactics" of Constantine VIII., where he directs "'flexible' (apparatus) with (artificial) fire, siphons, hand-siphons, and manjaniks" to be employed, if they are at hand, against any tower that may be advanced against the wall of a besieged town.[3] The "flexible" apparatus cannot refer to the helical springs of a later age. Neither can it

[1] "Nullus usquam in publico sipho, nulla hama, nullum denique instrumentum ad incendia;" *l.* x., *c.* 48, ed. Titze, p. 252.

[2] Ὄργανον ἐις πρόεσιν ὑδάτων ἐν τοῖς ἐμπρησμοῖς.

[3] Πρὸς δὲ τοὺς προσφερομένους πύργους ἐις τὸ τεῖχος, ἵνα ὦσι στρεπτὰ μετὰ λαμπροῦ καὶ συφώνια καὶ χειροσύφωνα καὶ μαγγανικά. In Meursii, Op. VI., 1349. In his "Lex. of Byzantine Greek" Sophocles gives λαμπρόν = φῶς, πῦρ.

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mean crossbows, for the Princess Anna, who wrote a century after Constantine, expressly says: "The crossbow (*tzangra*) is a foreign weapon (hitherto) unknown in the Greek service."[1] That it cannot mean longbows is quite certain from the second of the obscure passages in question, which occurs in the "Alexiad": "In the bow of each ship he (the Admiral) put the heads of lions and other land animals, made of brass and iron, gilt, so as to be (quite) frightful to look at; and he arranged that from their mouths, which were (wide) open, should issue the fire to be delivered by the soldiers by means of (or through) the 'flexible' apparatus."[2] The enemy might have exclaimed with the Jewish king: "They gaped upon me with their mouths, as a ravening and as a roaring lion." But whatever the moral effect of these trumpery scarecrows—if ever actually used—it is certain that archers with longbows could not have shot fire-arrows through them with any success; and the meaning of Emperor and Princess remains hidden until we interpret "flexible instrument" as the leathern hose of a pump or water-engine, than which nothing can be more flexible. The import of both passages then

[1] Ἡ δὲ τζάγγρα τόξον μέν ἐστι βαρβαρικὸν καὶ Ἕλλησι παντελῶς ἀγνοούμενον. "Alex.," ii. *c.* 8.

[2] Ἐν ἑκάστῃ πρώρᾳ τῶν πλοίων διὰ χαλκῶν καὶ σιδήρων λεόντων καὶ ἀλλοίων χερσαίων ζῴων κεφαλάς, μετα στομάτων ἀνεῳγμένων, κατασκευασας, χρυσῷ τε περιστείλας αὐτά, ὡς ἐκ μόνης θέας φοβερὸν φαίνεσθαι, τὸ διὰ τῶν στρεπτῶν κατὰ τῶν πολεμίων μέλλον ἀφίεσθαι πῦρ, διά τῶν στομάτων αὐτῶν παρεσκεύασε διιέναι. "Alex.," xi. 10. The obscurity in style of both the Royal writers was no doubt intentional.

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becomes perfectly plain. Such a mode of discharging incendiaries is by no means unknown in later military history. "Dans une expérience faite au Havre, 1758, avec une pompe à huile de naphte, dont le jet était enflammé par une mèche allumée, on brûla même une chaloupe."[1] At the siege of Charleston, 1863, not only was solidified Greek fire in tin tubes employed,[2] but coal naphtha placed in shells or pumped through hose.[3] Finally, M. Berthelot speaks of "les propositions faites, pendant le siège de Paris (1870), pour repousser les ennemis au moyen de pompes projetant des jets de pétrole enflammé. Mais cet agent . . . n'a été mis réellement à l'épreuve que par la Commune, pour brûler nos palais."[4]

When the Crusades began in 1097 the Greeks were thus in possession of two species of incendiaries: the sea-fire which was distinctively and exclusively Greek, and the old mixture of the Æneas family which was known all over the East. Yet it was to the latter that the name "Greek fire" was given by the Crusaders, who, I believe, had neither experience nor knowledge of the sea-fire. The only passage I can recall among the old writers in which the two fires are discriminated and correctly named occurs in the metrical romance

[1] Berthelot, *Revue des Deux Mondes*, Aug. 15, 1891, p. 800.

[2] American official "Hist. of the War of Rebellion," ser. 1, vol. xxviii. pt. 1, p. 33.

[3] "Greek Fire," in "Ency. Brit.," ninth ed.

[4] *Revue des Deux Mondes*, Aug. 15, 1891, p. 792.

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"Richard Coer-de-Lion," *temp.* Edward I. (1272–1307):—

> "Kyng Richard, oute of hys galye,
> Caste wylde-fyr into the skye
> And fyr Gregeys into the see.
> . . . . . .
> The see brent all off fyr Gregeys" (2627).[1]

Historically this passage is probably worthless; but, whether deliberately or by accident, the poet indicates the real distinction between the two fires. It was the sea-fire, the true Greek fire, which was thrown or fell into the sea; while the wild-fire, misnamed "Greek fire" by the Crusaders, was flung "into the sky" to descend on the heads of the enemy. In the preceding pages I have adopted the Crusaders' nomenclature, because it is now too late to rectify their blunder.

During the siege of Stirling Castle, 1304, Edward I. "gave orders for the employment of Greek fire, with which he had probably become acquainted in the East."[2] It was also made use of by the Flemish engineer, Crab, who took an active part in the defence of Berwick when besieged by Edward II. in 1319:—

> "And pyk (*pitch*) and ter (*tar*) als haiff thai tane,
> And lynt (*fat*) and herdes (*refuse of flax*) and brymstane,
> And dry treyis (*trees or wood*) that wele wald brin (*burn*)."[3]

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[1] Webber's "Metrical Romances."

[2] *Liber Gardrobæ* of Ed. I., in Tytler's "Hist. of Scotland," i. 181.

[3] Barbour's "The Bruce," bk. xvii., quoted by General R. Maclagan in *Journal of Asiatic Society of Bengal*, xlv. 30 *ff.*

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We again made use of Greek fire in the defence of the Castle of Breteuil, and in the attack on the Castle of Romorentin, in 1356;[1] but no record remains of its composition or of the way in which it was projected. It was no doubt similar to Whitehorne's wild-fire of 1560, given in Table II. As late as 1571 Greek fire was poured down on the heads of the Turks, in the primitive fashion, by the Venetians in the defence of Famagusta.[2]

The phrase "Greek fire" never took root in England, where "wild-fire" was early substituted for it. Wild-fire is found in Robert of Gloucester's "Chronicle,"[3] of the same date as "Richard Coer-de-Lion." According to the *Promptorium Parvulorum*, an English-Latin dictionary compiled in 1440 by Galfridus, a Dominican of Lynn Episcopi in Norfolk, the phrases "Greek fire" and "wild-fire" were then synonymous; for he gives as the Latin equivalents of the latter—"ignis Pelasgus, vel ignis pelagus, vel ignis Græcus." Among the ammunition supplied to the troops sent to Scotland under Lord Lennox in 1545, we find "xx tronckes charged with wylde fyer."[4] Whitehorne gives a plate of these tronckes or trombes, which were hollow wooden cylinders, "as bigge as a man's thigh and the length of an ell," filled with the mixture given in Table II. for

[1] Froissart, vol. i. pt. 2, *c.* 21, p. 332; *c.* 26, p. 337.

[2] Diedo, "Hist. of the Republic of Venise," ii. 228 *ff.*; Paruta, *Storia della Guerra di Cipro*, 88 *ff.*

[3] In Coleridge's "Dict. of the Oldest Words in the English Language."

[4] State Papers, Dom. Series, iii. 353.

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the sixteenth century. In Phillips' English Dictionary, 1706, wild-fire is described as (1) "a sort of fire invented by the Grecians about A.C. 777," and (2) "gunpowder rolled up wet and set on fire." It is used in the latter sense in "Robinson Crusoe," published in 1719. Before an attack on the Indians, the sailors "made some wild-fire . . . by wetting a little powder in the palms of their hands" (Part ii. chap. 21). The word is only heard now in the phrase "spreads like wildfire."

But though its names have passed away, the thing remains. Greek fire was used at the siege of Charleston in 1863; in 1870 M. Berthelot watched its effects when thrown into Paris by German guns; we ourselves possess it to this day in our Carcass composition.[1] The sea-fire, on the other hand, was comparatively short-lived, and I can find no certain evidence of its employment after the year 1200. Its disappearance is easily accounted for. From about the middle of the eleventh century the Byzantines began to show signs of an ever-increasing disinclination for war-service either afloat or ashore,[2] a want of national honour and military energy which Mr. Finlay ascribes to "a general deficiency of common honesty and personal courage;"[3] and this moral degeneracy threw naval duties more and more into the hands of the Venetians and other foreign mercenaries, to whom the Government may have been unwilling

[1] See Table II.

[2] E. Pears, "Fall of Constantinople," 1885, p. 211.

[3] "Hist. of Greece," iii. 492.

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to make known the secret of the sea-fire. This state of things did not escape the notice of Benjamin of Tudela, a Jewish traveller of the twelfth century: "(Les Grecs) entretiennent des soldats à gages de toutes les Nations qu'ils appellent Barbares, pour faire la guerre au Roi des Peuples de Togarma appellez Turcs. Car les Grecs eux-mêmes n'ont ni cœur ni courage pour la guerre. Aussi sont-ils reputez comme les femmes qui n'ont aucune force pour combattre."[1] Matters came to a crisis in 1200: in this year Michael Struphnos, the admiral commanding, sold the naval stores at Constantinople and appropriated the proceeds of the sale.[2] When, therefore, the pious warriors of the Fourth Crusade turned their arms against their fellow-Christians and beleaguered the city in April 1204, there was no sea-fire at hand for use against their ships, and an attempt to burn them by means of sixteen ordinary fire-ships was foiled by the activity of the Venetian sailors.[3] The accession of the Latin dynasty to the throne of Constantinople in this year was a serious hindrance to the re-

[1] "Voyages," &c. Trans. par Baratier, 1734, c. 6, p. 50.

[2] "Struphnos . . . turned into money not only the bolts and anchors of the ships but their sails and rigging, and left the navy without a single large ship" (ὁ Στρυφνὸς . . . δεινότατος ὢν μὴ μόνον γόμφους καὶ ἄγκυρας χρυσίου ἀλλάξασθαι ἀλλὰ καὶ λαίφεσιν ἐπιθέσθαι καὶ ἐξαργυρίσαι πρότονα, ἀπαξάπαντος πλοίου μακροῦ τὰ νεώρια Ῥωμαίων ἐκένωσε). *Nicetæ Hist.*, "De Alex. Isaac. Ang. Fr.," *l.* iii. p. 716. Sea-fire is not actually mentioned, but the man who made away with the fittings of the ships was not likely to spare the ammunition, if saleable.

[3] Ville-Hardouin, *La Conquête de Constantinople*, ed. Bouchon, 1891, p. 111.

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employment of sea-fire. The Latins were ignorant of its composition, and they were not likely to gain information upon the subject from the few Greeks who were acquainted with it; for these Christians did not love one another. Finally, saltpetre was discovered not many years afterwards, and its substitution for customary ingredients in the later editions of existing "Fire-books"[1] proves that it was utilised without delay for Greek fire, which thus became a more formidable incendiary than sea-fire.

The Greeks had no hand in the invention of cannon. One of their historians of the fifteenth century, when speculating on the subject in his narrative for the year 1389, says the Germans were commonly believed to have been the inventors.[2] Could the Greeks, then, have been in possession of saltpetre-mixtures many centuries before? Is it credible that people with intellect as keen as the Greeks employed an explosive for long ages without hitting upon the idea of metal guns? Yet judging from the manner in which Chalcocondyles speaks of cannon in his narrative for 1446, they were even then but little known to the Greeks. "Cannon,"

[1] See p. 14.

[2] Οἰονται δέ τινες καὶ τηλεβόλους καὶ τηλεβολίσκους ὑπὸ Γερμανῶν ἀρχὴν ἀποδεδειγμένους κ.τ.λ. Chalcocondyles, *Corp. Script. Hist. Byzant.*, ed. Niehbuhr, Bonn, 1843, *l.* ii. p. 72.

The tradition was widespread. Ariosto (1474–1533) says :—

> "La macchina infernal . . .
> Prima portata fu tra gli Alamanni."
>
> —*Orlando Furioso*, xi. 23.

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he tells his countrymen, "are formidable instruments, which no armour can resist, and which penetrates through everything."[1] No historian of the ability of Chalcocondyles would have spoken in this manner about an arm which was well known.

The fact that the first recorded use of fire-arrows on Greek soil was made by Persian archers,[2] lends some probability to the view that Greek fire was originally borrowed from the East; but the Greeks assuredly invented the sea-fire which was the palladium of the Empire for several centuries. To the discovery of saltpetre they have no legitimate claim. The claim put forward in their name is based partly on a metaphor,[3] partly on the assumption that the effects of sea-fire could have been only produced by a mixture containing saltpetre; and it cannot be sustained. The hypothesis that Kallinikos compounded a saltpetre mixture ignores the highly probable conclusion that saltpetre was not discovered until the thirteenth century;[4] fails to explain some statements, and is irreconcilable with

[1] Δεινὸν γάρ τοι ὁ τηλεβολίσκος, καὶ δυδὲν τῶν ὅπλων ἀντέχει ὥστε μὴ διαχωρεῖν διὰ πάντων καθικνούμενος. Ib., *l.* vii. p. 346.

[2] Herodotus, viii. 52, in his description of the taking of Athens during the invasion of Xerxes, 480 B.C.

[3] Μετὰ βροντῆς καὶ καπνοῦ. Leo's "Tactics," xix. 51. See p. 38, and Jähns, 515.

[4] "Dans notre opinion, les diverses compositions incendiares employées par les Arabes et par les Grecs, antérieurement à l'année 1225, ne contiennent pas de salpêtre."—Reinaud and Favé, *Journal Asiatique*, Oct. 1849, p. 282.

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other statements made by the ancients; and involves many incredible consequences.

It may be objected that this conclusion has been arrived at without taking the evidence of the chief witness for the Greeks, Marcus Græcus. Let us examine his *Liber Ignium*.

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CHAPTER IV

MARCUS GRÆCUS

(*Du Theil's text*[1] *with Berthelot's numeration*)

Incipit Liber Ignium a Marco Græco descriptus, cuius virtus et efficacia ad comburendos hostes tam in mari quam in terra plurimum efficax reperitur; quorum primus hic est.

1. Recipe sandaracæ puræ libram I., armoniaci liquidi ana. Haec simul pista et in vase fictili vitreato et luto sapientiæ diligenter obturato deinde (?); donec liquescat ignis subponatur. Liquoris vero istius haec sunt signa, ut ligno intromisso per foramen ad modum butyri videatur. Postea vero IV. libras de alkitran græco infundas. Haec autem sub tecto fieri prohibeantur, quum periculum immineret. Cum autem in mari ex ipso operari volueris, de pelle caprina accipies utrem, et in ipsum de hoc oleo libras II. intromittas. Si hostes prope fuerint, intromittes minus, si vero remoti fuerint, plus mittes. Postea vero utrem ad veru ferreum ligabis, lignum adversus veru grossitudinem faciens. Ipsum veru inferius sepo perungues, lignum prædictum in ripa succendes, et sub utre locabis. Tunc vero oleum sub veru et super lignum distillans accen-

[1] Paris MSS. 7156 and 7158, which may be dated 1300.

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sum super aquas discurret, et quidquid obviam fuerit concremabit.

2. Et sequitur alia species ignis quæ comburit domos inimicorum in montibus sitas, aut in aliis locis, si libet. Recipe balsami sive petrolii libram I., medulæ cannæ ferulæ libras sex, sulphuris libram I., pinguedinis arietinæ liquefactæ libram I., et oleum terebenthinæ sive de lateribus vel anethorum. Omnibus his collectis sagittam quadrifidam faciens de confectione prædicta replebis. Igne autem intus reposito, in aërem cum arcu emittes; ibi enim sepo liquefacto et confectione succensa, quocumque loco cecidit, comburit illum; et si aqua superjecta fuerit, augmentabitur flamma ignis.

3. Alius modus ignis ad comburendos hostes ubique sitos. Recipe balsamum, oleum Æthiopiæ, alkitran et oleum sulphuris. Haec quidem omnia in vase fictili reposita in fimo diebus XIV. subfodias. Quo inde extracto, corvos eodem perunguens ad hostilia loca sive tentoria destinabis. Oriente enim sole, ubicumque illud liquefactum fuerit, accendetur. Unde semper ante solis ortum aut post occasum ipsius præcipimus esse mittendos.

4. Oleum vero sulphuris sic fit. Recipe sulphuris uncias quattuor, quibus in marmoreo lapide contritis et in pulverum redactis, oleum iuniperi quattuor uncias admisces et in caldario pone, ut, lento igne supposito, destillare incipiat.

5. Modus autem ad idem. Recipe sulphuris splendidi quattuor uncias, vitella ovorum quinquaginti unum contrita, et in patella ferrea lento igne

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coquantur; et quum ardere inceperit, in altera parte patellae declinans, quod liquedius emanabit, ipsum est quod quæris, oleum scilicet sulphuricum.

6. Sequitur alia species ignis, cum qua, si opus, subeas hostiles domus vicinas. Recipe alkitran, boni, olei ovorum, sulphuris quod leviter frangitur ana unciam unam. Quæ quidem omnia commisceantur. Pista et ad prunas appone. Quum autem commixta fuerint, ad collectionem totius confectionis quartem partem ceræ novæ adicies, ut in modum cataplasmatis convertatur. Quum autem operari volueris, vesicam bovis vento repletam accipias et in foramen in ea faciens cera supposita ipsam obturabis. Vesica tali præscripta sæpissime oleo peruncta cum ligno marubii, quod ad haec invenietur aptius, accenso ac simul imposito, foramen aperies; ea enim semel accensa et a filtro quo involuta fuerit extracta, in ventosa nocti sub lecto vel tecto inimici tui supponatur. Quocumque enim ventus eam sufflaverit, quidquid propinquum fuerit, comburetur; et si aqua projecta fuerit, letales procreabit flammas.

7. Sub pacis namque specie missis nuntiis, ad loca hostilia bacleos gerentes excavos hac materia repletos et confectione, qui jam prope hostes fuerint, quo fungebuntur ignem jam per domos et vias fundentes. Dum calor solis supervenerit, omnia incendio comburentur.[1]

Recipe sandaracae (libram, cerae)[2] libram: in

[1] These lines are attached by Berthelot to No. 6.

[2] I have inserted these two words from the Nürnberg MS. (Romocki, i. 124), instead of the unmeaning "horatactinæ."

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vase vero fictili, ore concluso, liquescat. Quum autem liquefacta fuerint, medietatem libræ olei lini et sulphuris superadjicies. Quæ quidem omnia in eodem vase tribus mensibus in fimo ovino reponantur, verum tamen fimum ter in mense renovando.

8. Ignis quem invenit Aristoteles quum cum Alexandro ad obscura loca iter ageret, volens in eo per mensem fieri id quod sol in anno præparat. Ut in spera de auricalco, recipe æris rubicundi libram I., stanni et plumbi, limaturæ ferri, singulorum medietatem libræ. Quibus pariter liquefactis, ad modum astrolabii lamina formetur lata et rotunda. Ipsam eodem igne perunctam X. diebus siccabis, duodecies iterando: per annum namque integrum ignis idem succensus nullatenus deficiet. Quæ enim inunctio ultra annum durabit. Si vero locum quempiam inunguere libeat, eo desiccato, scintilla quælibet diffusa ardebit continue, nec aqua extingui poterit. Et haec est prædicti ignis compositio. Recipe alkitran, colophonii, sulphuris crocei, olei ovorum sulphurici. Sulphur in marmore teratur. Quo facto universum oleum superponas. Deinde tectoris limaginem ad omne pondus acceptum insimul pista et inungue.

9. Et sequitur alia species ignis, quo Aristoteles domos in montibus sitas destruere incendio ait, ut et mons ipse subsideret. Recipe balsami libram I., alkitran libras V., oleum ovorum et calcis non extinctae libras X. Calcem teras cum oleo donec una fiat massa; deinde inunguas lapides ex ipso et herbas ac renascentias quaslibet in diebus caniculari-

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bus, et sub fimo eiusdam regionis sub fossa dimittes; postea [1] namque auturnnalis pluviæ dilapsu succenditur. Terram et indigenas comburit igne Aristoteles, namque hunc ignem annis IX. durare asserit.

10. Compositio inextinguibilis et experta. Accipe [2] sulphur vivum, colophonium, asphaltum classam, tartarum, piculam navalem, fimum ovinum aut columbinum. Hæc pulverisa subtiliter petroleo; postea in ampulla reponendo vitrea, orificio bene clauso, per dies XV. in fimo calido equino subhumetur, Extracta vero ampulla destillubis oleum in cucurbita lento igne ac cinere mediante, calidissima ac subtili. In quo si bombax intincta fuerit ac accensa, omnia super quæ arcu vel ballista proiecta fuerit, incendio concremabit.

11. Nota quod omnis ignis inextinguibilis IV. rebus extingui vel suffocari poterit, videlicet cum aceto acuto aut cum urina antiqua vel arena, sive filtro ter in aceto imbibito et toties desiccato ignem iam dictum suffocas.

12. Nota quod ignis volatilis in aëre duplex est compositio; quorum primus est:—recipe partem unam colophonii et tantum sulphuris vivi, II. partes vero salis petrosi et in oleo linoso vel lamii [3] quod est melius, dissolvantur bene pulverisata et oleo liquefacta. Postea in canna vel ligno excavo re-

[1] Berthelot reads "primo."

[2] "Take" is here "accipe" instead of the "recipe" used in the nine preceding recipes.

[3] Berthelot reads, "lauri."

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ponatur et accendatur. Evolat enim subito ad quemcumque locum volueris, et omnia incendio concremabit.

13. Secundus modus ignis volatilis hoc modo conficitur. Accipias libram I. sulphuris vivi, libras duas carbonum vitis vel salicis, VI. libras salis petrosi; quae tria subtilissima terantur in lapide marmoreo. Postea pulvis ad libitum in tunica reponatur volatili vel tonitrum faciente.

Nota, quod tunica ad volundum debet esse gracilis et longa et cum prædicto pulvere optime conculcato repleta. Tunica vero tonitrum faciens debet esse brevis et grossa et prædicto pulvere semiplena et ab utraque parte fortissime filo ferreo bene ligata. Nota, quod in tali tunica parvum foramen faciendum est, ut tenta imposita accendatur; quæ tenta in extremitatibus sit gracilis, in medio vero lata et prædicto pulvere repleta. Nota, quod quæ ad volandum tunica, plicaturas ad libitum habere potest; tonitrum vero faciens, quam plurimas plicaturas. Nota, quod duplex poteris facere tonitrum atque duplex volatile instrumentum, videlicet tunicam includendo.

14. Nota, quod sal petrosum est minera terræ et reperitur in scopulis et lapidibus.[1] Haec terra dissolvatur in aqua bulliente, postea depurata et destillata per filtrum, permittatur per diem et noctem integram decoqui; et invenies in fundo laminas salis congelatas cristallinas.

15. Candela quæ, si semel accensa fuerit, non

[1] Better, "in scrophulis contra lapides," Berthelot's reading.

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amplius extinguitur. Si vero aqua irrigata fuerit, maius parabit incendium. Formetur sphaera de ære Italico; deinde accipies calcis vivæ partem unam, galbani mediam et cum felle testudinis ad pondus galbani sumpto conficies. Postea cantharides quot volueris accipies, capitibus et alis abscisis, cum aequali parte olei zambac, teras et in vase fictili reposita, XI. diebus sub fimo equino reponantur, de quinto in quintum diem fimum renovando. Sic olei foetidi et crocei spiritum assument, de quo sphæram illinias; qua siccata, sepo inguatur, post igne accendatur.

16. Alia candela que continuum præstat incendium. Vermes noctilucas cum oleo zambac puro teres et in rotunda ponas vitrea, orificio lutato cera Græca et sale combusto bene recluso et in fimo, ut iam dictum est, equino reponenda. Quo soluto, sphæram de ferro Indico vel auriculco undique cum penna illinias; quæ bis iuncta et dessiccata igne succendatur et nunquam deficiet. Si vero attingit pluvia, majus præstat incendii incrementum.

17. Alia quæ semel incensa dat lumen diuternum. Recipe noctilucas quum incipiunt volare, et cum æquali parte olei zambac commixta, XIV. diebus sub fimo fodias equino. Quo inde extracto, ad quartam partem istius assumas felles testudinis, ad sex felles mustelæ, ad medietatem fellis furonis. In fimo repone, ut iam dictum ut. Deinde exhibe in quolibet vase lichnum, cujuscumque generis, pone de ligno aut latone vel ferro vel ære. Ea tandem hoc oleo peruncta et accensa dinturnum præstat in-

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cendium. Haec autem opera prodigiosa et admiranda Hermes et Tholomeus[1] asserunt.

18. Hoc autem genus candelæ neque in domo clausa nec aperta neque in aqua extingui poterit. Quod est: recipe fel testudinis, fel marini leporis sive lupi aquatici de cuius felle Tyriaca. Quibus insimul collectis quadrupliciter noctilucarum capitibus ac alis præcisis adicies, totumque in vase plumbeo vel vitreo repositum in fimo subfodias equino, ut dictum est, quod extractum oleum recipias. Verum tum cum æquali parte prædictorum fellium et æquali noctilucarum admiscens, sub fimo XI. diebus subfodias per singulares hebdomades fimum renovando; quo iam extracto de radice herbæ que cyrogaleonis[2] et noctilucis pabulum factum, ex hoc liquore medium superfundas. Quod si volueris, omnia repone in vase vitreo et eodem ordine fit. Quolibet enim loco repositum fuerit, continuum præstat incendium.

19. Candela quæ in domo relucet ut argentum. Recipe lacertam nigram vel viridem, cuius caudam amputa et desicca; nam in cauda eius argenti vivi silicem reperies. Deinde quodcumque lichnum in illo illinitum ac involutum in lampade locabis vitrea aut ferrea, qua accensa mox domus argenteum induet colorem, et quicumque in domo illa erit, ad modum argenti relucebit.

20. Ut domus quælibet viridem induat colorem

[1] This is the reading of the Paris MS. 7156. Ptolemy is here spelt as Chaucer spells it, *Tholome*; "Boece," ii. 7.

[2] Probably a scribe's blunder for *cynoglossi*.

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et aviculæ coloris ejusdem volent. Recipe cerebrum aviculæ in panno involvens tentam et baculum, inde faciens vel pabulum in lampade viridi novo oleo olivarum accendatur.

21. Ut ignem manibus gestare possis sine ulla læsione. Cum aqua fabarum calida calx dissolvatur, modicum terræ Messinæ, postea parum malvæ visci adicies. Quibus insimul commixtis palmam illinias et desiccari permittas.

22. Ut aliquis sine læsione comburi videatur. Alceam cum albumine ovorum confice, et corpus perungue et desiccari permitte. Deinde coque cum vitellis ovorum iterum, commiscens terendo super pannum lineum. Postea sulphur pulverisatum superaspergens accende.

23. Candela quæ, quum aliquis in manibus apertis tenuerit, cito extinguitur; si vero clausis, ignis subito renitebitur: et haec millies, si vis, poteris facere. Recipe nucem Indicam vel castaneam, eam aqua camphoræ conficias, et manus cum eo inungue, et fiet confestim.

24. Confectio visci est cum si aqua projecta fuerit, accendetur ex toto. Recipe calcem vivam, eamque cum modico gummi Arabici et oleo in vase candido cum sulphure confice; ex quo factum viscum et aqua aspersa accendetur. Hac vero confectione domus quælibet adveniente pluvia accendetur.

25. Lapis qui dicitur petra solis in domo locandus, et appositus lapidi qui dicitur albacarimum (*alba ceraunia?*). Lapis quidem niger est

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et rotundus, candidas vero habeus notas, ex quo vero lux solaris serenissimus procedit radius. Quem si in domo dimiseris, non minor quam ex candelis cereis splendor procedit. Hic in loco sublimi positus et aqua compositus relucet valde.

26. Ignem Græcum tali modo facies. Recipe sulphur vivum, tartarum, sarcocollam et picem, sal coctum, oleum petroleum et oleum gemmæ. Facias bullire invicem omnia ista bene. Postea impone stuppam et accende, quod, si volueris, exhibere (poteris ?) per embotum ut supra diximus.[1] Stuppa illinita non extinguetur, nisi urina vel aceto vel arena.

27. Aquam ardentem sic faciés. Recipe vinum nigrum spissum et vetus et in una quarta ipsius distemperabuntur unciæ II. sulphuris vivi subtilissime pulverisati, lib. II. tartari extracti a bono vino albo, unciæ II. salis communis; et subdita ponas in cucurbita bene plumbata et alembico supposito destillabis aquam ardentem quam servare debes in vase clauso vitreo.

28. Experimentum mirabile quod fecit homines ire in igne sini læsione vel etiam portare ignem vel ferrum calidum in manu. Recipe succum bisvalvæ et albumen ovi et semen psillii et calcem et pulverisa; et confice cum albumine succis (?) raphani et commisce. Et ex hac commixtione illinias corpus tuum et manum et desiccare permitte et post iterum illinias; et tunc poteris audacter sustinere sine nocumento.

[1] There seems to have been some *lacuna* in a previous recipe.

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29. Si autem velis ut videatur comburi, tunc accenditur sulphur, nec nocebit ei.

30. Candela accensa quæ tantam reddit flammam quæ crines vel vestes tenentis eam comburit. Recipe terebenthinam et destilla per alembicum aquam ardentem, quam impones in vino cui applicatur candela et ardebit ipsa.

31. Recipe colophonium et picem subtilissime tritum et ibi cum tunica proicies in ignem vel in flammam candelæ.

32. Ignis volantis in aëre triplex est compositio. Quorum primus fit de sale petroso et sulphure et oleo lini, quibus tritis, distemperatis et in canna positis et accensis, poterit in aërem sufflari.

33. Alius ignis volans in aëre fit ex sale petroso et sulphure vivo et ex carbonibus vitis vel salicis; quibus mixtis et in tenta de papiro facta positis et accensis, mox in aërem volat. Et nota, quod respectu sulphuris debes ponere tres partes de carbonibus, et respectu carbonum tres partes salpetræ.

34. Carbunculum gemmæ lumen præstantem sic facies. Recipe noctilucas quam plurimas; ipsas conteras in ampulla vitrea et in fimo equino calido sepelias et permorari permittas per XV. dies. Postea ipsas remotas destillabis per alembicum et ipsam aquam in cristallo reponas concavo.

35. Candela durabilis maxime ingeniosa fit. Fiat archa plumbea vel ænea omnino plena intus et in fundo locetur canale gracile tendens ad candelabrum, et præstabit lumen continuum oleo durante.

Explicit Liber Ignium.

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[1] There is no Index to the original. The above has been made for the convenience of the reader.

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M. Berthelot (i. 100 *ff.*) gives the best existing text of the foregoing tract, founded on Paris MSS. 7156 and 7158 collated with the Munich MS. 267. He adds extracts from the Munich MS. 197, dated 1438. Herr von Romocki gives the text reproduced here and the Nürnberg MS. of a somewhat later date than the Paris MSS., say 1350.[1]

A glance at the text given here shows that, far

[1] i. *c.* 4. There is a marked similarity between certain numerals to be found in Kyeser's "Bellifortis," 1405, and those used in the Nürnberg MS. Romocki, i. 124, 150.

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from being a formal and connected treatise, it is a medley of recipes thrown together with very little method and without any literary skill. Of the thirty-five recipes (in Du Theil's MS.) fourteen are war mixtures, six relate to the extinction of incendiaries or the prevention and cure of burns, eleven are for lamps, lights, &c., and four describe the preparation of certain chemicals—one of them, No. 14, giving a mode of refining saltpetre. The war mixtures consist of nine recipes for various fires, Nos. 1, 2, 3, 6, 7, 8, 9, 24, and 26; one for fire-arrow composition, No. 10; and four for rockets and Roman candles (including a "cracker"), Nos. 12, 13, 32, and 33. Nos. 9, 15, and 24 contain quicklime; 12, 13, 14, 32, and 33 contain saltpetre.

A closer examination leads to the conclusion that the tract is the work of neither one author nor one period. As we read of such ingredients as weasel's gall (17) and paste of glow-worms (16); of the mercury to be found in black and green lizards' tails (19); of the mixture which ignites incontinently at sunrise, wherewith crows are to be anointed and despatched against the enemy (3), we seem to hear the chant of the witches in "Macbeth":—

> "Eye of newt and toe of frog,
> Wool of bat and tongue of dog,
> Adder's fork and blind-worm's sting,
> Lizard's leg and owlet's wing."

These recipes embody the same traditions as the war recipes of the "Kestoi" of Sextus Julius Afri-

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canus, which belong to the seventh century. But on turning to Nos. 32 and 33, we find recipes as precise and formal as those of Hassan er-Rammah, who wrote in the last quarter of the thirteenth century. The description of the rocket and its composition (13) is as definite and intelligible as many a recipe of the seventeenth century: recipes 8 and 17, with their allusions to Hermes, the mythical Alexander the Great, Aristotle the wizard and Ptolemy the magician, belong to a far earlier period. In short, the extraordinary contrast in style and matter, phraseology and diction, between certain recipes and others, leads irresistibly to the conclusion that the oldest recipes are separated from the youngest by several centuries, and that the tract (as we possess it) was not the work of one man, but of several. There is a kernel of old recipes, to which others were added from time to time. This conclusion receives strong support from the fact that no two of the MSS. are of the same length. The Munich MS. contains twenty-two, Berthelot's text thirty-five, and the Nürnberg MS. twenty-five recipes.

The best judges date the oldest existing MSS., Paris, 7156 and 7158, at about 1300 A.D., and Abd Allah tells us that saltpetre was known to the Spanish Arabs in the second quarter of the thirteenth century.[1] The saltpetre recipes, therefore, 12, 13, 14, 32, 33, lie between the years 1225 and

[1] See p. 16. He was born near Malaga.

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1300. We shall call them, for convenience of reference, the "Late Recipes."

No one who carefully studies the remaining recipes can fail to observe that many of them are marked by archaism of style, form and matter, and that they hand down to us ancient alchemical traditions, or traces of them; while others display no such peculiarities. Let us then, again for mere convenience, divide them into two series — the "Early Recipes," which possess these peculiarities, and the "Middle Recipes," which do not. To what periods do these two series belong?

No. 26, apparently the most modern of the Middle Recipes, will presently be shown to belong to the early part of the thirteenth century, and, as it does not contain saltpetre, its approximate date is 1200–1225. There is no evidence, so far as I am aware, which would enable us to fix the beginning of the Middle or the end of the Early Recipes. The matter, happily, is immaterial; it is sufficient for us to know that the former series is undoubtedly subsequent to the latter, and (as will be shown) quite independent of it.

For a reason which will appear presently, the date of the oldest of the Early Recipes depends upon the period at which Moslems began to write upon alchemy. According to Arab authorities,[1] the first Moslem who wrote on the subject was Prince Khalid ibn Yazeed ibn Moawyah, who died in 708. After him came the real Jabir, of the eighth or

[1] Berthelot, iii. 2.

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ninth century; but Masudi, in the tenth century, tells us that there were many other writers on alchemy whose names are now lost.[1] The very earliest date, then, that can be assigned to the oldest of the Early Recipes is the eighth century, say 750.

The three series are as follows:—

Early Recipes, 750– ?	Middle Recipes, ? –1225.	Late Recipes, 1225–1300.
1, 2, 3, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20, 21, 23, 25, 34	4, 5, 11, 22, 24, 26, 27, 28, 29, 30, 31, 35	12, 13, 14, 32, 33

Looking from the chemical point of view, M. Berthelot divides the recipes into six groups.[2] Those who are interested in the matter will find on examination that, chronologically, his groups harmonise perfectly with the three series given here.

The reader will observe on a cursory examination of the Latin text that most of the recipes contain foreign, *i.e.* non-Latin words; and this fact suggests the question, Is the *Liber Ignium* an original work or a translation?

The number of foreign words and allusions is so considerable as to leave little doubt that a large part of the tract was translated from some foreign

[1] "Golden Prairies," Paris ed., viii. 177.

[2] i. 128–132.

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language, and no one, I believe, seriously maintains that the work, as a whole, is original. From what language, then, has it been translated?

We meet with the Greek proper names Hermes, Ptolemy, Alexander and Aristotle, and with a number of Greek words which look like survivals of a Greek original. Among the most prominent are alba ceraunia (?), asphaltum,[1] bombax, cynoglossum (?), orichalcum and sarcocolla, all of which are latinised Greek words. But on looking closely into this evidence we find that it has very little weight. The Greek proper names prove nothing. Hermes and Ptolemy became common property to alchemists of all nationalities in the infancy of alchemy. Alexander the Great's extraordinary career excited universal wonder, and the many and marvellous legends which grew round his name in the West were only surpassed by those of the East. He and his Wazir, Aristu (Aristotle), were common property long before the *Liber Ignium* saw the light. The Greek words give no support to the hypothesis of a Greek original unless it can be shown either that they had not previously been adopted by the Latins, or that the tract was written before they were borrowed. A particular instance will make the matter clearer. We took the word *harquebus* from the French at some period, say *p*. If harquebus occurs in an English book written after *p*, its presence raises no presumption that the book was in any way connected with France,

[1] Not a genuine Greek word, although used by Herodotus.

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or even that its author understood French. If the book was written before *p*, its author must have had recourse, directly or indirectly, to French sources. Now all the Greek words given above had been latinised long before the *Liber Ignium* was written, and might have been used by a Latin when translating from any language. Alba ceraunia, asphaltum, bombax, cynoglossum and sarcocolla are found in Pliny's "Natural History," first century A.D., and orichalcum occurs in the "Bragging Soldier" of Plautus about the end of the third century B.C. But it is unnecessary to continue the examination of the Greek words contained in the tract for the following reason. A hypothesis must cover all the facts of a case, and some facts in the present case are inexplicable on the theory of a Greek original.

The Greeks had three words for the asphalt family, *pissa*, *asphaltos*, and *naphtha;* and the translator had at least three Latin words (which he has actually used) wherewith to translate them, *pix* (or *picula*), *asphaltum*, and *petroleum*. How, then, came he to use the barbarism, *alkitran Græcum*, in recipe 1? The original of this phrase came from no Greek source.

We could not expect the author of the tract to reveal the secret of the sea-fire, which was only known to a few officials; but the mediæval Greeks were not an exceptionally modest people, and we naturally look for some slight allusion to this triumphant incendiary and the siphons in which

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it was employed. They are never referred to, although ballistæ, bows, and rockets are mentioned in recipes 10, 12, 13, 32, 33.

The title of the tract, *Liber Ignium, a Marco Græco descriptus*, assuming it to have been correctly and literally translated, was not written by a Byzantine Greek. No Byzantine Greek ever described himself (or a compatriot) as a Greek: "in the lowest period of degeneracy and decay the name of *Roman* adhered to the last fragments of the Empire of Constantinople."[1] The writer of the title, therefore, was either a Moslem or a western.

The author of recipe 26, *Ignem Græcum*, &c., was neither a Greek nor a Moslem. No Greek[2] or Moslem[3] writer ever uses the phrase "Greek fire," which sprang up in the West during the Crusades.[4] The recipe, therefore, cannot have been written before the siege of Nice, 1097, the first act of the first crusade, and it was probably not written until long afterwards. The phrase "Greek fire" must have taken some time to reach the West, and it spread there very slowly. Abbé Guibert de Nogent, who died in 1124, speaks of "discharging from machines the fire they call Greek" (*Græcos, quos ita vocitant, Ignes injicere machinis*).[5] At the close of the century William the Little, Canon of St. Mary's, Newburgh, Yorkshire, mentions "a certain kind of fire which they call Greek" (*quodam ignis genere quem*

[1] Gibbon, vi. 103, Bury's ed.
[2] Romocki, i. 7 *n.*
[3] Reinaud and Favé, p. 49.
[4] Jähns, 512 *n.*
[5] "Hist. Hierosol.," *l.* vii. *c.* 33.

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Græcum dicunt).[1] Such modes of expression show that Greek fire was very little known in the West during the twelfth century. In the *Liber Ignium*, on the other hand, it is spoken of without qualification or explanation, like sulphur or pitch, as a substance too well known to require note or comment. The 26th recipe, therefore, belongs very probably to the first quarter of the thirteenth century, and its author was certainly a western.

The hypothesis of a Greek original, then, must be abandoned, even though old Greek alchemical traditions are crystallised in the Early Recipes. The Greeks founded alchemy in remote times; their methods were transmitted through the Syrians and Egyptian Greeks to the Moslems; and a large number of their recipes had become common property long before the *Liber Ignium* was written. But Greek science did not spread equally in all directions, at least to any appreciable extent. It spread to the south and east only, and the west owed its knowledge of alchemy to the Arabs who invaded Spain in 710 A.D. This fact may throw some light upon the Arabic words and allusions to be found in the tract.

In a very old recipe, No. 9, we meet with the phrase, "the first fall of the autumnal rain" (*primo autumnalis pluviae dilapsu*), which indicates the regular, periodic rains of the East, and is apparently the translation of خريف (kharif) = the autumnal

[1] *Hist. Rerum Anglicarum*, *l.* iv. *c.* 19. A work carried up to the year 1198.

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rains. The beginning of these rains was an event of great importance to the Arabs. "Suivant Masudi," says Baron de Sacy, "les Arabes nomment l'automne وسمی (*wasmy*), à cause des pluies qui tombent en cette saison, parceque la terre, étant alors très-sèche, et n'ayant pas été humectée depuis longtemps, la première pluie qui vient à tomber imprime sa marque sur la terre. . . . Il ajoute que les Arabes commencent l'année à l'équinoxe d'automne, parceque c'est l'époque où commence à tomber la pluie à laquelle ils doivent leur subsistance."[1]

Alambicum is apparently the latinised form of the Spanish *alambique*, which is simply the Arabic الانبیق (*al-ambiq*)—whatever the derivation of the Arabic word may be.

استرلاب (*Asturlab*), although found in Masudi[2] and the "Arabian Nights,"[3] is not a genuine Arab word. It was borrowed from some other language by the Arabs, who possessed few or no scientific words of their own. The "Nihayet al-Adab" tells us (in Lane's "Arabic Dictionary," under *asturlab*) that the names of all instruments by which time is known, whether by means of calculation or water or sand, are foreign to the Arabic language. In most Arabic dictionaries *asturlab* is derived from the Greek ἀστρολάβος, a word which appears to go back no further than the second century B.C., when

[1] In his summary of Masudi's "Book of Indication and Admonition," appended to the "Golden Prairies," Paris ed., ix. 311.

[2] Ib., i. 198.

[3] "Tale of the Tailor," i. 280, 285, Burton's ed., 1894.

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it was employed by the Egyptian astronomer, Ptolemy. But it was long suspected that the instrument was of eastern origin,[1] and all doubt about the matter was at length set at rest by Mr. George Smith's discovery, in the palace of Sennacherib at Nineveh, of the fragment of an astrolabe,[2] which cannot be dated later than the eighth century B.C. Now the earliest recorded astronomical observation made by the Greeks was the determination of the summer solstice by Meton, 430 B.C.[3] For the name of this fragment, therefore, we must look to the language of the country of its birth; and there we find the Persian *asturlab*, which is apparently formed from the primitive verbal root *labh* = taking,[4] and the Persian *astar* or *sitára* = Pehlevi, *çtârak* = Zend, *çtare* = Sanskrit, *star* = our own *star*. The Arabs most probably took their *asturlab*, with so many other words, from the Persian. The Greeks who followed Alexander the Great into Persia found there much that was new to them. They saw for the first time "the cotton tree and the fine tissues and paper for which it furnished the materials."[5] They handled the wool of the great Bombax tree. They found naphtha, of whose properties Alexander was entirely ignorant.[6] They

[1] "Archæologia," xxxiv. 261.

[2] "Assyrian Discoveries," p. 407.

[3] R. Grant, "Hist. of Physical Astronomy," p. 435.

[4] Prof. Whitney, "Language and the Study of Language," 1867, p. 259.

[5] Humboldt's "Cosmos," ii., pt. ii. p. 523, Bohn's ed.

[6] Plutarch, "Alexander," 35.

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obtained drugs and gums of which they knew nothing. The philosopher Kallisthenes discovered in Babylon Chaldæan astronomical observations extending back to 721 B.C.;[1] was shown, we cannot doubt, the instrument with which they were made; and probably heard for the first time the word *asturlab* or *usturlab*.

For copper (or some alloy of it[2]) the *cyprium* of Pliny (which became *cuprum* about the end of the third century A.D.) is ignored in the tract, and the metal is called *æs rubicundus*. This phrase may possibly represent the χαλκὸς ἐρυθρός of Homer (Il. ix. 365); but it is far more probably the literal translation of the Arabic phrase used to this day for copper نحاس احمر (*nuhas ahmar*) = red brass.

Four (so-called) sulphurs are mentioned by both Pliny and the writers of the *Liber Ignium*, but their names are identical in only one case, *sulphur vivum*. Two sulphurs are named in the tract from their colour, after the oriental fashion, *sulphur splendidum* and *sulphur croceum*. Masudi speaks in the tenth century of "white, yellow, and other kinds of sulphur,"[3] and "white and red sulphur" are mentioned in the *Ayin Acberi*, a Persian MS. quoted by the Baron de Sacy.[4] Several sulphurs, all named from their colour, are given in the *Liber Secretorum*, translated from the Arabic or Persian, *cir.* 1000 A.D.,[5]

[1] Humboldt, ib.

[2] "Le mot χαλκος et le mot *æs* en latin comprennaient à la fois le cuivre et ses alliages colorés en rouge ou en jaune."—Berthelot, ii. 122 *n*.

[3] "Golden Prairies," Paris ed., iii. 49.

[4] *Chrestomathie Arabe*, iii. 456.

[5] Berthelot, i. 306.

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and similar sulphurs are found in the Syriac treatise reproduced by M. Berthelot, ii. 159–60. Finally, the Hindus had four sulphurs, white, red, yellow, and black.[1]

The Arabs had no special word for bitumen: *bitumen* is not to be found in the tract.

Alkitran, the Spanish *alquitran*, which is used five times, is pure Arabic, القطران (*al-qitran*).

In three successive recipes we meet an Arabic word in its native form, without any attempt to translate it—زنبق (*zembaq*). Its meaning is doubtful, for a reason given by Baron de Sacy: "Le nom zambak est commun à plusieurs plantes. Forskål le donne à *l'iris* et au *lis blanc*."[2]

We have already met with two Arabic words which were adopted unchanged, and are still used, by the Spaniards, alembic and alkitran. There are other traces of Spain.

Roger Bacon observes in his "Greek Grammar" (p. 92) that the alloy *auricalcum* is in no way connected with *aurum*, gold, but is a corruption of *orichalcum*. The Spaniards, however, retained in their language the corrupt form auricalco, and auricalcum occurs twice in the tract.

We may gather from Lebrixa's explanation of "bitumen Judaicum"—"est quod græce dicitur asphaltos"[3]—that the Spaniards had no special word for asphalt; *asphaltum* is used only once in the tract,

[1] Rāy's "Hindu Chemistry," p. 50.
[2] *Chrestomathie Arabe*, ii. 482.
[3] *Dict. Lat.-Hispanico*, 1570, but written half a century before.

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recipe 10. But they used *petroleo* for petroleum;[1] *petroleum* is found in recipes 2, 10, and 26. This word, in the form *petra oleum*, is used in the Anglo-Saxon "Leechdoms," published in the Rolls Series, which Rev. O. Cockayne, the editor, dates at 900; ii. 289. The Spaniards did not use the word *naphtha*, which is described by Lebrixa as "el fuego como de alquitran." *Naphtha* does not occur in the tract, although it is found in Latin and Greek authors of the first and second centuries A.D.; in Pliny's "Natural History," ii. 109 (105); in Dioskorides, i. 101; and in Plutarch's "Alexander," 35. It appears as *naphathe* in the "Speculum" of Vincentius Bellovacensis, 1228; *l.* i. *c.* 92. The commonest Spanish word for one or other of the asphalt family, *alquitran*, occurs (as before mentioned) five times in the tract.

On referring to the Chemical Index, p. 68, it will be found that all the foregoing Arabic and Spanish words occur in the Early Recipes. The Middle Recipes contain only one Arabic word, *alambic*, recipes 27 and 30, which is also found in the Early Recipes, No. 34; and one Spanish word, *petroleo*, recipe 26, which occurs twice in the earlier series, Nos. 2 and 10. Now, Spain was the only European country in which Arabic was understood during the Middle Ages. "In all Europe, outside Spain, but three isolated Arabists of that time are known—William of Tyre, Philip of Tripoli, and Adelard of

[1] Minsheu, "Span.-English Dict.," 1623.

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Bath."[1] Pagnino printed an edition of the Qur'an at Venice in 1530, and it was immediately suppressed by the Church; "a precaution hardly required," says Hallam, "while there was no one able to read it."[2] Furthermore, we know that a series of Latin translations of Hebrew and Arabic MSS. were made in Spain between the years 1182 and 1350.[3] We may therefore conclude with some little probability:—

1°. That the Early Recipes were translated from a lost Arabic original.

2°. That the translator was a Spaniard.

3°. That the translation was made between the years 1182 and 1225.

4°. That to this translation were added by other hands, before 1225, the Middle Recipes, which practically contain neither Hispanicism nor Arabism, and which make no mention of saltpetre.

5°. That the Late Recipes were inserted towards the close of the thirteenth century.[4]

On accepting these conclusions, the difficulties raised by the hypothesis of a Greek original vanish. The Spanish translator had no need to translate the *alkitran* of the Arabic writer, for the word was Spanish as well as Arabic. Like all westerns, he called the Byzantines Greeks, and a certain incendiary Greek fire. Neither Moslem nor Spaniard was

[1] Mr. Fitzmaurice-Kelly, "Hist. of Spanish Literature," p. 19. He is speaking of the Crusade period.

[2] "Literature of Europe," &c., *c.* ix. § 4.

[3] Berthelot, i. 232.

[4] Ib., i. 130, 135.

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likely to speak of the sea-fire. Moslems would be loth to recall the disasters at Cyzicus and elsewhere, when this incendiary made havoc of their ships; Spaniards knew nothing about it. Owing to the secrecy maintained by the Imperial Government, westerns knew very little about Byzantine pyrotechnics. "At the end of the eleventh century the Pisans . . . suffered the effects, without understanding the cause, of the Greek fire."[1] The Princess Anna Comnena ascribes the defeat of the Pisans in a naval battle fought in 1103, to an unknown incendiary employed by the Greeks.[2] In both cases the incendiary could only have been the sea-fire, for the Latins had been acquainted with ordinary incendiaries for a thousand years. As late as 1204, the Emperor Baldwin I., in a manifesto to all Christians, declares that the Greeks used "machines and defences to protect their capital (in this year) which no one (from the West) had ever seen before."[3]

It is time to inquire who was Marcus Græcus. He has been fancifully identified with many of the Marci of history and fable, and M. Dutens discovered him in the second century A.D. The views of M. Dutens must be noticed here, because they have been unwarily adopted by some good writers.

There exists a Latin translation of a lost Arabic treatise on medicine, *De Simplicibus*, supposed by some to have been written by Masawyah of Damas-

[1] Gibbon, vi. 11, Bury's ed. [2] *Alexiad*, xi. 10.

[3] "Urbem machinis et propugnaculis munit (Alexius), quorum similia nemo viderit unquam."—Duchesne, *Hist. Franc. Script.*, v. 279.

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cus in the eleventh century,[1] while others, with M. Dutens, assign it to Yahya ibn Masawyah, who attended the Caliph Mamoun on his deathbed,[2] 833 A.D. The question before us is, does the *De Simplicibus* (whatever its date) contain any reference to Marcus? When mentioning the use of syrup of cyclamen, Masawyah quotes the opinions of other physicians: "The son of Serapion said (so and so) . . . and a Greek (physician) says (so and so)" (*dixit filius Serapionis . . . et dicit Græcus*).[3] On the last two words, *dicit Græcus*, M. Dutens builds his theory that the Greek physician was no other than Marcus: "Ce qui paroît fort probable, est que (Marcus Græcus) devoit vivre avant le médicin arabe, Mesué, qui a paru au commencement du neuvième siècle, puisque celui-ci le cite.[4] By this mode of reasoning, which is generally called "begging the question," Marcus Græcus may be identified at will with any Greek who ever lived. M. Dutens continues: "Fabricius croit que (Mar-

[1] "Ency. Brit.," xv. 805.

[2] "The Golden Prairies" of Masudi, Paris, 1873, vii. 100.

[3] "J. Mesuæ . . . Opera," Venice, 1581, p. 85. Fabricius thought this Greek physician might have been Gereon (*qui forte est Gereon*), *Bibliotheca Græca*, Hamburg, 1718–52, xiii. 172. I cannot follow MM. Reinaud and Favé and Herr von Romocki in identifying him with Dioskorides. The evidence (from the description of the cyclamen and the preparation of the syrup) seems to point the other way. The past tense, *dixit*, in the passage in the text, would seem to show that Ibn Serapion was dead when it was written. The present tense, *dicit*, indicates similarly that "Græcus" was then living, a contemporary of Masawyah's. Yet Dutens speaks of his having lived "avant le médicin arabe."

[4] *L'Origine des Découvertes*, 1796, p. 198.

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cus Græcus) est le même dont Galen parle dans un endroit de ses ouvrages, au quel cas il serait du temps requis pour appuyer mon sentiment." It would be strange indeed to find mention of a Latin writer or book in a *Bibliotheca Græca*, and I have failed to verify M. Dutens' reference. In the editions of Fabricius' work which I have consulted he expresses no such belief, nor does he allude to Marcus Græcus. In the list Fabricius gives of ancient physicians there are several who bear the name of Marcus, but no Marcus Græcus. The last of these Marci happens to be simply called "Marcus," and of him Fabricius says: "This Marcus, who is mentioned by Galen in his book on compounding medicines, may possibly have been one of the foregoing" (*Marcus, simpliciter, Galeno in compositionibus medicamentorum* κατὰ τόπους, *l.* iv. *c.* 7, *quem credibile fuisse unum ex illis prioribus*).[1]

The *Liber Ignium* was written from first to last in the period of literary forgeries and pseudographs, which produced the "Book of Hermes," "The Domestic Chemistry of Moses," the alchemical works of Plato and of Aristotle and of the Emperor Justinian, and so on; and we may reasonably conclude that Marcus Græcus is as unreal as the imaginary Greek original of the tract which bears his name.

Had the last editor of the *Liber Ignium*, who added the saltpetre receipts, any knowledge of an explosive?

[1] *Bibliot. Græc.*, xiii. 320. His *Bibliot. Latina* contains no allusion to Marcus Græcus. Galen died in 200 A.D.

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We need not linger over the Roman candle of No. 12, or the rocket of No. 13: had their charges been explosive there would have been an end of the candle and rocket, and of the men who fired them. The cracker of No. 13 was a toy intended to "go off with a bang," without hurt to the bystanders. The case was to be as strong as possible and securely fastened at both ends with iron wires. It was to be half filled with rocket composition, a mixture which burned in a cracker-case precisely as it burned in a rocket-case—with progressive combustion. Now Roger Bacon had a similar toy, constructed with the very same object, *i.e.* "to go off with a bang," the case of which was "merely a bit of paper." Why was there this marked difference, then, between the two cases? Because the noise was produced in the one by the explosion of the charge and in the other by the rupture of the case. Bacon's charge (as will be shown in Chap. viii.) was gunpowder, and the required "bang" was directly produced by its explosion. Marcus' toy was charged with an incendiary, the combustion of which did not produce a "bang" directly, but which produced one indirectly by ultimately bursting open the thick, stout case. The gases generated by its combustion "gradually developed until the case burst,"[1] just as a bladder bursts "with a bang" when over-inflated. Had Bacon's toy been charged with an incendiary, the case, which was only a sheet of paper, would have been set on fire by the heated gases long before their

[1] Guttmann, "Manufac. of Explosives," 1895, i. 8-9.

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pressure had reached the bursting point, and there would have been no "bang." Had Marcus' toy been charged with an explosive, it would have exploded destructively, and what was intended for a public diversion would have proved a common danger, owing to the thickness of the case and the iron wire coiled round it. There is nothing in the tract to show that its authors had any notion of explosives, and their silence, without any assignable motive, is strong evidence that they knew nothing about them. It is incredible that pyrotechnists who seldom omit to call attention to the effects of their incendiaries,[1] should have failed to make some allusion to explosives if they possessed them. Their silence was not owing to fear of the Church, for the decree of the Second Council of the Lateran was directed against the very mixtures which form the staple of the *Liber Ignium*, incendiaries.[2] The 12th and 13th recipes contain the ingredients of the future gunpowder; they form the last link in the long chain of evolution which connects the incendiaries of primitive times with gunpowder; but they were not gunpowder, because they did not explode. The chrysalis, we know, will become a butterfly if it lives; nevertheless it would be an abuse of language and a misrepresentation of fact to call it a butterfly.

The reader can now appreciate the value of

[1] Recipes 1, 2, 10, &c.

[2] "Artem illam mortiferam et Deo odibilem balistariorum et sagittariorum adversus Christianos et Catholicos exerceri de cetero sub anathemate prohibemus."—*Concil. Rom.*, ann. 1139, *c.* 30.

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the argument that the Greeks possessed an explosive between the seventh and thirteenth centuries, *because* Marcus Græcus describes one; and he can understand why Marcus was not summoned in Chap. iii. to give evidence for the Greeks.

A suspicion may be raised by the Arabic origin of the *Liber Ignium*, that the people who approached so nearly to the manufacture of gunpowder may have ultimately reached it. We pass, therefore, to a consideration of Arabic incendiaries in the following chapter.

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CHAPTER V

THE ARABS

ALTHOUGH the Arabs had had relations with the Greeks, Romans, and Persians for centuries, and were acquainted with the details of the siege of Jerusalem, 70 A.D., the earliest allusion to their use of machines is the tradition that Jodhaimah, King of Heerah, constructed manjánik in the third century A.D.[1] The scarcity of timber in Arabia may partially explain the lateness of their introduction, and the position of Heerah, in the north-east province of Arabian Irak, raises a suspicion that the Arabs learned the use of machines from the Persians, who got them from the Greeks.

When the Prophet besieged Tayif in 8 A.H. (630 A.D.), the defenders had recourse to heated projectiles.[2] We may safely assume that they were the balls of hot clay spoken of in the 11th Sura of the Qur'an, in describing the destruction of the Cities of the Plain: "we rained upon them stones of baked clay."[3] Half a century afterwards, 683, during the siege of Mecca, the Ka'aba was burned

[1] Caussin de Perceval, *Essai sur l'hist. des Arabes*, ii. 17.

[2] Muir's "Life of Mahomet," p. 432; Caussin de Perceval, iii. 257.

[3] Devout Moslem commentators explain "baked" to mean "baked in hell." See Sale's trans. *ad loc.*

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down by incendiary compositions, discharged, not by Arabs, but by Syrians, who doubtless understood the manipulation of naphtha and the other combustibles used.[1] In 712 the howdah in which sat Dahir, King of Alor in Scinde, was set on fire by a fire-arrow shot by a Moslem naphtha-thrower[2]—the same nature of projectile that had been used by the Persian archers at the taking of Athens, 480 B.C. In speaking of the capture of Alor, both Mir Ma'sum Bhakkari, in his "History of Scinde," and Haidar Razi, in his "General History," mention the employment of *atish bazi*, or fire-throwing machines, "which the Moslems had seen in use with the Greeks and Persians."[3] Stones were discharged from machines to so little purpose at the siege of Heraclea, 805, that Harun er-Reshid urged his generals to fasten incendiaries to them. This was done with such effect that the resistance of the besieged at once collapsed, the inhabitants being terror-stricken at the sight of the flaming naphtha.[4] There is no trace of an explosive here, yet a French Arabist would have us believe that muskets were in use during this Caliph's reign.

Al-bunduqani, the man who carries a *bunduq*, which in this connection is a contraction for *qaus al-bunduq*, or simply *qaus bunduq*,[5] was an epithet bestowed on Harun by the public, or

[1] Masudi's "Golden Prairies," Paris ed., v. 166.
[2] "Chachnama," in Elliot, i. 170.
[3] Ib., vi. 462.
[4] Masudi, ii. 350.
[5] See Burton's note, "Arab. Nights," xii. 38.

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assumed by himself; and in translating one of the "Arabian Nights" with this title, M. Gauttier remarks: "Bondouk signifie en Arabe harquebuse, albondoukani signifie l'arquebusier."[1] This argument may be illustrated by a more familiar one: "Jonathan gave his artillery unto his lad" (1 Sam. xx. 40); but artillery signifies cannon; therefore, &c. &c. It may be remarked that *arquebuse* is ambiguous. "Avant d'être une arme à feu l'arquebuse était une arme à jet," says Dr. Dozy,[2] who is supported by M. Scheler: "l'arquebuse était à son origine une sorte d'arbalète."[3] Assuming, however, as Gauttier evidently did, that *arquebuse* meant a firearm, his argument only establishes the use of firearms in the ninth century, if we take *signifie* as equivalent to *means now, in the year* 1822, *and meant also in the time of Harun.* The question, therefore, turns upon the meaning of the words *bunduq*, or *qaus bunduq*, in the time of the great Caliph, and an anecdote told by Masudi leaves no doubt about what that meaning was.[4] He tells us that in the time of Muhtadi Billah, 868–9, a negligent porter was sentenced by his master to be tied up (apparently in a room or courtyard) and shot at fifty times by a man armed with a *qaus bunduq*, which carried leaden *bunduq*. There is not the slightest allusion to charge, cartridge, gunpowder,

[1] I have been unable to find a copy of Gauttier's "Arab. Nights," Paris, 1822, and quote him as given in Burton, xii. 38.

[2] *Supplement aux Dictionaires Arabes*, Leyden, 1877, under قوس.

[3] *Dict. d'Etymologie Française*, Brussels, 1888.

[4] viii. 17–18.

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wad, or match, nor to the operation of loading. The ammunition consisted solely of leaden balls. Although the marksman sent his fifty *bunduq* home, the porter was so little the worse for his punishment that, when all was over, he made a coarse but cutting remark to his tormentor. There can be no question of firearms here: one, or at most two bullets fired by so good a shot from any firearm ever constructed would have silenced the porter for ever. The marksman was *al-bunduqani*, the *bunduq* were leaden balls, and the *qaus bunduq* was a pellet-bow = stone-bow[1] = گلولہ کمان (golulé keman) = *golail*, used to this day by the Karens of Burma, and known to everybody who has been in India. Such is the explanation of *qaus bunduq* given by the commentator Tabrizi in a note on one of Motanebbi's poems—a bow which discharges a ball as big as a hazel nut.[2] The bow itself is a long-bow with two strings joined at their centre by a bit of cloth or soft leather, which supports a ball generally of baked clay or stone. If Hansard's plate be correct, the western stone-bow was a cross-bow with two strings.[3] The golail, as we learn from one of the oldest of the "Arabian Nights," was chiefly used for shooting birds, squirrels, &c.: "he shooteth birds with a pellet of clay,"[4] ببندقة من طين. Again,

[1] "Hailstones full of wrath shall be cast as out of a stone bow."—"Wisdom of Solomon," v. 22. "Oh for a stone bow, to hit him in the eye!"—"Twelfth Night," ii. 5.

[2] Sacy, *Chrestomathie Arabe*, iii. 68.

[3] "The Book of Archery," London, 1840, p. 236.

[4] Burton's ed., 1894, ii. 338.

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when the first Kalandar missed his bird and hit the Wazir in the eye, he was using a *qaus al-bunduq*,[1] قوس البندق. The insult conveyed by the words of the Sultan Kai-kubad, when speaking of the dead leader of the Mughals, lay in the fact that the golail was not a soldier's weapon, but merely a sporting implement: "No one would condescend to shoot an arrow at a dead body; it is only a pellet-ball that is fit for such (carrion) as this."[2] We need not pursue the matter further: in the primitive and simple golail is found the musket carried by the Caliph Harun er-Reshid.

From a passage in the "Chachnama," given in Barnes' "Travels into Bokhara," it is clear that the Moslems in their invasion of India relied upon incendiaries to meet the attacks made upon them with elephants, which are very much afraid of fire. At the battle of Alor, 712, already mentioned, the Moslems "filled their pipes" (*hukkaha-e atish bazi* = grenades or siphons) "and returned with them to dart fire at the elephants" (i. 67). This fact goes far to explain a difficulty raised by the words *toofung* (musket) and *tope* (cannon) found in some MSS., in place of the *khudung* (arrow) and *nuft* (naphtha) given in other copies of Ferishta's account of the battle fought near Peshawur in 1008. He says: "On a sudden the elephant upon which the prince who commanded the Hindus rode, becoming unruly from the effects of the *naphtha balls* and the flights of *arrows*, turned and fled. This circumstance pro-

[1] Burton's ed., 1894, i. 98. [2] Elliot, iii. 526.

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duced a panic among the Hindus, who, seeing themselves deserted by their general, gave way and fled also."[1] The best critics reject the readings *musket* and *cannon* in this passage. These words were unknown to other Indian historians, and the circumstances of the case make the use of an incendiary exceedingly probable.

"I am slow in believing this premature use of artillery," says Gibbon; "I must desire to scrutinise first the text and then the authority of Ferishta." "These readings must be due to interpolators," adds Professor Bury.[2] "It appears likely," says General Briggs, the translator of Ferishta, "that Babar was the first invader who introduced great guns into Upper India, in 1526, so that the words *tope* and *toofung* have been probably introduced by ignorant transcribers of the modern copies of this work, which are in general very faulty throughout."[3]

Sir H. M. Elliot says: "The *Tarikh-i Yamini*, the *Jami'u-t Tawarikh* of Rashidu-d Din, the *Tarikh-i Guzida*, Abu'l Fida, the *Tabakat-i Nasiri*, the *Rauzatu'-s Safa*, the *Tarikh-i Alfi* and the *Tabakat-i Akbari*, though almost all of them notice this important engagement . . . and mention the capture of thirty elephants, yet none of them speak of either *naft* or *tope*."[4]

Finally, we must remember that there is an abundant supply of naphtha in the neighbourhood of Peshawur,[5] and that the practice of throwing

[1] Elliot, vi. 219. [2] "Decline and Fall," &c., vi. 226 *n*.
[3] In Elliot, vi. 455. [4] Ib. [5] Ib., 456.

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incendiary missiles was universal in Asia long before the battle in question. The Ka'aba, as we have seen, was burnt down by incendiaries in 683, and this tremendous event of course became instantly known all over Islam. At the battle of Alor, 712, the Moslems specially prepared incendiaries to repulse the attacks of the elephants. Igneous projectiles were employed by Harun er-Reshid in 805 at the siege of Heraclea. The last day of the siege of Baghdad, 813, is described by the poet Ali as "a day of fire": "the machines played from the hostile camps . . . and fire and ruin filled Baghdad."[1] So well known were incendiary shell in Persia at the close of the tenth century that Firdusi mentions them in the episode of Nushirvan and Porphyry: "The Romans began the fight from the gates and discharged arrows and pots (of fire)."[2] In 1067 Shems al-Mulk Nasr, when besieging Bokhara, ordered incendiaries to be discharged against some archers posted in the minaret of the Grand Mosque. The wooden roof of the minaret took fire, the sparks fell upon the main building, and in the end the whole mosque was burned down.[3]

[1] In Masudi's "Golden Prairies," *c.* 93 :—

وعملت المنجنيقات بين الفريقين وكثر الحريق والهدم ببغداد

A large number of instances of the actual use of incendiaries in Asia will be found in General Maclagan's "Early Asiatic Fire Weapons," *Jour. Asiatic Soc. of Bengal*, xlv. p. 30 *ff.*

[2] *Shahnama*, Mohl's ed., vol. vi. p. 212, *l.* 628 :—

زدروازها جنگ برساختند همی تیر و قرورة انداختند

[3] Schefer, *Chrestomathie Persane*, i. 48–49.

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We may rest assured, then, that the words Ferishta wrote in his account of the battle near Peshawur, 1008, were *naphtha* and *arrow*, not *musket* and *cannon*.

Far from possessing muskets in the ninth century, there is no evidence to show that the Arabs had fire-arms, that is, arms charged with an explosive, during the whole of the Crusade period, 1097–1291. So strange and deadly an agent of destruction as gunpowder could not possibly have been employed in the field without the full knowledge of both parties; yet no historian, Christian or Moslem, alludes to an explosive of any kind, while all of them carefully record the use of incendiaries. The Arab accounts of these campaigns will be found collected together in M. Reinaud's *Extraits des Historiens Arabes relatifs aux guerres des Croisades*, Paris, 1829; the Christian accounts are scattered in various volumes; but they teach us no more than we have learnt already in the two preceding chapters about incendiaries and Greek fire: "les projectiles incendiaires ont pu rester à peu près les mêmes pendant toutes ces Croisades."[1]

At the siege of Nice, first Crusade, we read of the Saracens throwing balls of pitch, oil and fat against the machines of the Christians.[2] Fire-arrows bearing pitch, wax, sulphur, and tow were discharged from the walls of Jerusalem during the siege in the same Crusade.[3]

[1] Reinaud and Favé, p. 65.
[2] William of Tyre, *Hist.*, &c., Paris, 1844, p. 123.
[3] Bongars, *Gesta Dei per Francos*, p. 178.

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During the second Crusade we find the Arabs making use of similar incendiaries,[1] mixtures practically identical with that of Æneas Tacticus, *cir.* 350 B.C., given in Table II. Shell full of burning naphtha were used at the siege of Acre, 1189–91, in the third Crusade;[2] and Richard of England, on his voyage thither, sank a ship which an eye-witness had seen laded at Beyrut with ballista, bows, arrows, and lances, and a large supply of Greek fire secured in bottles (*ignem Græcum abundanter in phialis*),[3] a phrase which reminds us of the 18th recipe of the *Liber Ignium* of Marcus Græcus: "put the mixture in a glass bottle" (*hoc in vase vitreo ponatur*). For the sixth Crusade, we have the invaluable *Histoire du Roy Saint Loys* of Joinville, who describes the terror excited by the incendiaries of the Moslems, believed by all to be the work of the Powers of Darkness. "Quant le bon chevalier Messire Gaultier mon compagnon vit ce feu, il s'escrie et nous dist: Seigneurs, nous sommes perduz á jamais sans nul remède. Car s'ilz bruslent nos chaz chateilz, nous sommes ars et bruslez; et si nous laissons nos gardes, nous sommes ahontez . . . Et toutes les fois que nostre bon Roy saint Loys oyoit qu'ils nous gettoient ainsi ce feu, il se jettoit à terre, et tendoit ses mains la face levée au ciel, et crioit à haulte voix à nostre Seigneur, et disoit en pleurant à grans larmes: Beausire Dieu Jesuchrist,

[1] Albert d'Aix, in Reinaud and Favé, p. 62.
[2] Boha ed-Din, ib.
[3] T. Gale, *Hist. Anglicani Scriptores*, Oxford, 1687, ii. 327.

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garde moy et tout magent," &c.[1] Yet the incendiaries which created all this panic appear to have wounded but few and to have killed nobody!

Although no evidence is forthcoming to show that explosives were used in Palestine during the Crusade period, there is good evidence, it has been said, to prove that gunpowder was used by the Arabs in Spain during the thirteenth century.

The first, I believe, to start the theory that the Spanish Arabs possessed gunpowder at this early period was Michael Casiri, a Maronite, who was librarian of the Escorial and published his *Bibliotheca Arabico Hispana Escurialensis* in 1760–70; and his method of supporting his theory when translating the MS. of Shehab ben Fadhl, which he dates at 1249, was the simple one of translating *barud* by *pulvis nitratus*, the recognised Latin phrase for gunpowder.[2] Had he translated *barud* by *saltpetre* no difficulty could have arisen, since an Arab alchemist, Abd Allah, states that saltpetre was so called in the West during the second quarter of the thirteenth century.[3] There would be nothing surprising, therefore, in finding saltpetre mixtures employed in Spain at this period; but saltpetre mixtures, such as the last three given in Table II., are not necessarily explosive. Not only is Casiri's translation of *barud* unwarrantable, but he probably

[1] Paris ed., 1668, p. 39 *ff*.

[2] ii. 7. Milton uses the phrase, *nitrati pulveris igne*, in his juvenile Latin poem, "In Quintum Novembris," *l.* 120.

[3] See p. 17. He was a Spanish Arab, born near Malaga.

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dates his MS. a century too early. M. Reinaud, a safe guide, believes that the MS. is Al-Omari's, and dates 1349,[1] eighteen years after the siege of Cividale where the Germans used cannon,[2] and three years after Cressy where we certainly had guns.[3]

Casiri's methods are well illustrated by his translation of an Arabic passage relating to the siege of Baza, 1325, by Ismael ben Nasr, King of Granada. The literal translation of the passage is as follows: "He (the King) marched through the enemy's country to the town of Baza, which he invested and attacked. By means of a great machine provided with naphtha (made up in) hot (burning) balls, he struck the arch of an inaccessible tower."[4] According to Casiri the passage reads: "Shifting his camp, he besieged with a large army the town of Baza, where, by applying fire, he discharged (*explosit*) with much noise a great machine, provided with naphtha and a ball, into a fortified tower."[5] He introduces, it will be observed, an explosion

[1] Reinaud and Favé, p. 66 *n*. If this Arab is identical with Shaykhun al-Omari, the Egyptian grand amir, he died in 758 A.H. (1356 A.D.). Sacy's *Chrest. Arabe*, i. 272.

[2] Jähns, p. 775.

[3] See "Cannon at Cressy," by the present writer, *Proceed. R.A. Inst.*, vol. xxvi.

[4] وعمل الحركة الى بلاد العدوّ الى مدينة بسطة فاخذ فى حلقها ونشر الحرب عليها ورمى بالآلة العظمى المتحدة بالنفط كرة مجماة طاقة البرج المنيع.
—*Bib. Arab. Hispan.*, ii. 7.

[5] "Ille castra movens, multo milite, hostium urbem Baza obsedit, ubi machinam illam maximam naphta et globo instructam, admoto igne, in munitam arcem cum strepitu explosit."—Ib.

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(*explosit*) into a passage which neither mentions nor suggests one. The application of fire has no place in the original, and suggests the ignition of an explosive charge. He changes the meaning of the original by gratuitously inserting an *and* between naphtha and ball, which were one and the same thing. He leaves us to infer that the charge was naphtha, though it was not explosive and could not project a ball. He speaks of the explosion being accompanied by a loud noise, of which there is nothing in the original. The incendiary balls are mentioned in another Arabic account of this siege, translated by Conde in his *Historia de la Dominacion de los Arabes en Espagna*, p. 593: "The Arabs attacked the city night and day with machines and engines which threw balls of fire with a loud noise" (*combatio la ciudad de dia y noche con maquinas é ingenios que lanzaban globos de fuego con grandes truenos*).

In this passage the discharge of the incendiary balls is said to have been accompanied by "thunderings," and at the siege of Niébla, 1257, we are again told that the Moors "launched stones and darts from machines, and missiles of thunder with fire" (*lanzaban piedras y dardos con maquinas, y tiros de trueno con fuego*).[1] From this innocent metaphor, *trueno con fuego*, the Emperor Leo's "thunder with smoke," has been wrenched the meaning that the Arabs possessed a train of artillery. "Il n'y a rien à cela que de vraisemblable,"

[1] Conde, p. 559.

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says the Emperor Napoleon III.[1] Nothing, I venture to think, can be more unlikely. The Arab writer is dealing with machines which, he says in his own way, discharged stones and darts, and also igneous missiles which burned with much noise. Another Arab, already quoted (p. 4), gives a freer rein to his fancy: the projectiles "roar like thunder; they flame like a furnace; they reduce everything to ashes." In plain words, they are incendiaries. The writer makes no allusion to the effect of their momentum or shock; he impresses on us the effect of their essential quality—their incendiary power, exaggerating the noise made by their combustion. Joinville writes in a similar style of Greek fire: "La manière du feu grégeois estoit telle . . . Il faisoit tel bruit à venir qu'il sembloit que ce fust fouldre qui cheust du ciel . . . et gettoit si grant clarté qu'il faisoit aussi cler dedans nostre ost comme le jour, tant y avoit grant flamme de feu."[2] Unless we make due allowance for the luxuriant Oriental imagination, we may despair of ever being able to reach the meaning of the Eastern writers. One of them wants to explain that the ditch of a fort was deep and wide, and he tells us it was "broad as the ocean and fathomless."[3] Wishing to state that on the arrival of the army on its banks, the Nerbudda, which happened to be in flood, subsided quickly, another writer says: "You might say

[1] iii. 83-4.
[2] *Hist. du Roy Saint Loys*, Paris, 1668, p. 69 *ff.*
[3] Elliot, ii. 219.

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that it (the river) was a remnant of the universal deluge. As the miraculous power of the saintly Sultan accompanied the Army, all the whirlpools and depths became of themselves immediately dry on the arrival of the Army, and the Musulmans passed over with ease."[1] A similar indulgence in metaphor, although not so unbridled, is found in European writers. For instance, Vegetius likens the projectile hurled by an onager to a thunderbolt;[2] and the Princess Anna Comnena compares the fiery particles blown by the breath through a popgun, or spitfire, to lightning.[3]

It is hardly necessary to examine the accounts given by Conde of the siege of Tarifa, 1340, and by Casiri of the siege of Algesiras, 1342, since both sieges took place some years after that of Cividale, 1331. The reader will find the two accounts ably analysed in Reinaud and Favé, pp. 70–74.

If the Arabs had possessed an explosive in the thirteenth century, the fact must have been known to their alchemists, and they show no such knowledge. There is not an allusion to saltpetre in the Leyden Arabic MS. of 1225.[4] Hassan er-Rammah, who died in 1295, knew nothing of explosives. In speaking of saltpetre in the year 1311, Yusuf ibn Ismaël al-Juni says: "The people of Irak use it to make a fire which tends to rise and move. Saltpetre

[1] Elliot, iii. 79.
[2] *Saxa fulminis more contorquet*, De Re Militari, iv. 22.
[3] Ὡσπερ πηγαστήρ, Alex., xiii. 3.
[4] Reinaud and Favé, in *Journal Asiatique*, Oct. 1849, p. 281.

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increases the ease and rapidity of ignition."[1] This sentence contains the sum total of Yusuf's knowledge of saltpetre mixtures. He was aware of the effects of their progressive combustion, but he knew nothing about their explosive combustion.

By whomsoever gunpowder was invented, it was not by the Arabs.

[1] وهم يستعملونه فى اعمال النار المتصاعدة والمتحركة فيزيدها خفة وسرعة التهاب .

Reinaud and Favé, p. 78. The fire which "rises and moves" is of course rocket composition.

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CHAPTER VI

THE HINDUS

In the third quarter of the eighteenth century, by order of Warren Hastings, a committee of Brahmins collected a body of Gentoo (or Hindu) laws from a number of ancient Sanskrit books. These laws were translated into Persian under the superintendence of one of the Brahmins, and the Persian version was translated into English in 1776 by Mr. N. B. Halhed, Bengal Civil Service. In his preface he states that gunpowder had been known in India "far beyond all periods of investigation," a conclusion arrived at by a method now familiar to the reader: "the word 'firearms' is literally in Sanskrit *agni astra*. . . Cannon in the Sanskrit idiom is *shataghni*."

Agni is found in the Latin *ignis* = fire; *astra*, Romocki explains, is connected with the Slav *ostr* = point (of an arrow, &c.); and the compound *agniastra* is simply a fire-arrow or rocket. In the *shataghni*, or "hundred killer," we have some weapon described in the exaggerated style usual in early times and by no means confined to India. When Sigurd struck an anvil with his sword Gram, "he cleft it down to the stock thereof;"[1] and "if

[1] *Völsunga Saga*, translated from the Icelandic by Magnusson and William Morris, p. 51.

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one smote a mountain" with al-Mahik (the annihilator) the sword of Gharib, "'twould overthrow it."[1] There is nothing to connect the *shataghni* with fire: indeed it seems to have been a mace, for in the "Raghuvansa" the demon is said to have laid his iron-headed shataghni upon Rama, just as Kuvera laid his club on Jamraj.[2] No mention of any projectile discharged by an explosive is to be found in Manu's "Code of Laws," and to Manu belongs a passage in the "Code of Gentoo Laws" (p. 53) which either Halhed has mistranslated from the Persian, or the Persian translators have mistranslated from the Sanskrit. Professor Rāy has unearthed the original text of Manu (vii. 90), and gives the correct translation: "The king shall not slay his enemies in battle with deceitful or barbed or poisoned weapons, nor with any having a blade made red hot by fire,[3] or tipped with burning materials."[4] Halhed's translation is: "The magistrate shall not make war with any deceitful machine, or with poisoned weapons, or with cannon and guns, or with any other kind of firearms." Mephistopheles was right:—

> "Mit Worten lässt sich trefflich streiten,
> Mit Worten ein System bereiten."

Halhed's mistakes might have been forgotten had they not been revived and elaborated by Pro-

[1] Burton's "Arab. Nights," 1894, v. 242.

[2] Elliot, vi. 471 *n.*

[3] *e.g.* the red-hot ploughshare wielded with much effect by Bailie Nicol Jarvie at the Clachan of Aberfoyle.

[4] "Hindu Chemistry," pp. 97–8.

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fessor G. Oppert in an essay "On the Weapons, &c., of the Ancient Hindus," London, 1880. His argument is briefly this: firearms are clearly mentioned in the "Laws of Manu" and two very ancient Sanskrit poems; therefore at some very remote period the Hindus possessed an explosive which, for whatever reason, fell into disuse eventually.

"Does the passage in Manu refer to firearms or not?" asks Dr. Oppert. "In our opinion it certainly alludes to them" (p. 70). We need not recur to the mistranslation of Manu already noticed.

The two poems on which Dr. Oppert relies for further evidence are the *Nitiprakásika* of Vaisampayana, and the *Sukraniti* of Sukra. According to the former, the Hindu deities, Sita, Indra, Krishna, &c., were authors of "books on polity." Brahma's contribution to literature consisted of 10,000,000 double verses (p. 36). The constitution of an army was as follows (p. 5):—

Foot	2,187,000,000
Horse	21,870,000
Elephants	218,700
Chariots	21,870

The "arms in use" of one species were forty-four in number; of another species, fifty-five. Rabelais has only succeeded in cataloguing forty-six arms in the introduction to the third book of "Pantagruel." Lest the ninety-nine arms in use might fail to ensure success, a spell (of thirty-two syllables) is given (p. 10) which would bring certain victory to him

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who repeated it 32,000 times. Both of these veracious works, however, undoubtedly mention cannon and muskets, and a recipe for gunpowder is given in the *Sukraniti*.[1]

Dr. Oppert makes no critical examination of the texts of these poems to ascertain whether they contain the interpolations to be found in most Oriental works. Of their age he only says that "no Chinese work . . . can, with respect to antiquity, be compared with the *Sukraniti*" (p. 45). As the reader will find in the following chapter, this implies a considerable age.

It is hard to believe that gunpowder was known to a people whose language contained no word for saltpetre;[2] that cannon were used by men whose books make no allusion to gunpowder, with the exception just mentioned. "It is peculiar," says Dr. Oppert, "that powder should not have been mentioned in Sanskrit works" (p. 63). The same peculiarity is observable in Anglo-Saxon works, and is probably due to the same cause. But the fatal objection to the existence of this very early explosive is the admitted fact that after a time it was discarded and forgotten. Writers who lightly tell us so are apparently unconscious of the greatness of the demand they make upon our credulity. They ask us, in effect, to accept the astonishing proposition, that a nation voluntarily surrendered, without any assignable cause, an incalculable "advantage" in the "struggle for existence"—the eager, continuous,

[1] Given by Rāy, "Hindu Chemistry," p. 96. [2] See p. 15.

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and unending preparation for self-defence which is, in Mr. Bagehot's words, "the most showy fact" in human history. It is infinitely more probable that the passages in the two poems which mention gunpowder and cannon were interpolated by the scribes of after-ages than that the Hindus wantonly broke the first and strongest law of human nature, the law of self-defence. There can be no reasonable doubt that the recipe for gunpowder in the *Sukraniti* is an interpolation. The proportions are given in the first place as 5 : 1 : 1, and then it is added, "if the powder is to be used for a gun," let them be 4 : 1 : 1, or 6 : 1 : 1.[1] And why not 5 : 1 : 1 also? This recipe was not written by a gunner: it is the handiwork of some charlatan of the sixteenth or seventeenth century, who imagined that, by making a certain mystery about the proportions 5 : 1 : 1, he should give a semblance of great antiquity to the recipe. But he blundered badly about the proportions. The proportions 4 : 1 : 1 were only reached by the Swedes about the middle of the sixteenth[2] century, and approached by the English about the middle of the seventeenth,[3] and powder of such strength would have blown weak, early bombards to pieces. Other sound reasons are given by competent critics for rejecting from first to last the allusions to firearms contained in the two poems. A critic in *Nature* points out that a work which mentions the Hunas (Huns or Europeans) cannot be of the age appa-

[1] Rāy's "Hindu Chemistry," p. 96.
[2] See Table VIII. [3] See Table VII.

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rently assigned by Dr. Oppert to the *Nitiprakásika*.[1] "Oppert," says Sir R. Burton, "shows no reason why the allusions to, and descriptions of, gunpowder and firearms should not be held modern interpolations into these absurd compositions."[2] Mr. W. F. Sinclair concludes from the strong resemblance between the firearms described and those which we know were imported into India during the sixteenth and seventeenth centuries, either that the MSS. date no further back than the sixteenth century, or that the allusions to firearms were interpolated at that period.[3] "One is naturally led to suspect," says Professor Rāy, "that the lines (of the *Sukraniti*) relating to gunpowder . . . are interpolations." The suspicion is further enhanced when it is borne in mind that in the "Polity of Kamandaki," an ancient work of undoubted authenticity, "there occurs no reference whatever to firearms, nor is there any in the *Agnipurana*, in which the subject of training in the use of arms and armour takes up four chapters. . . . The more rational conclusion would be that the *Sukraniti* is a patchwork, in which portions of chap. iv. were added some time after the introduction of gunpowder in Indian warfare during the Moslem period."[4] "The last chapter is apparently spurious," says Rajendralala Mitra, "as it describes guns as they existed a hundred years ago."[5] Finally,

[1] Oct. 21, 1880.
[2] "Camoens," &c., ii. 632 *n*.
[3] "Indian Antiquary," 1878.
[4] "Hindu Chemistry," pp. 96–7.
[5] "Notices of Sanskrit MSS.," v. 135.

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Herr von Romocki utterly rejects Dr. Oppert's theory.[1]

The military history of India confirms the conclusions of the writers who have been quoted: not a fact is to be found there which lends any support to the theory of early gunpowder in India.

The employment of gunpowder in Europe revolutionised the art of war and affected, more or less, almost every human institution. "The military art," says Gibbon, "has been changed by the invention of gunpowder . . . Mathematics, chymistry, mechanics, architecture, have been applied to the science of war."[2] Gunpowder, says A. Comte, "en emprimant à l'art de la guerre un caractère de plus en plus scientifique, a directement tendu à intéresser tous les pouvoirs à l'actif dévellopement continu de la philosophie naturelle."[3] We may reasonably assume that the discovery of so tremendous an agent as gunpowder would have produced in India some few effects, at least, similar in their general features to the effects it produced in Europe. To mention one or two details: Sanskrit would have coined a word for saltpetre, which it did not possess; the use of the bow would have been curtailed; a lasting mark would have been put on fortifications; and some few specimens of the early firearms might have survived. Not a trace of these or similar changes is to be found; not a vestige of early firearms has remained. General Cunningham thought

[1] i. 36. [2] "Decline and Fall," &c., iv. 166, Bury's ed.
[3] "Philosophie Positive," vi. 114.

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that the state of the ruins of certain ancient Kashmir temples proves the use of an explosive in their destruction,[1] but more prolonged observation shows that their condition is chiefly the effect of natural agencies. "The fingers of Time, and moderate movements of the earth, have been making openings in some of the other old Hindu buildings in Kashmir," such as the little temple of Payach and the splendid temple of Martand; "and from their appearance it may be believed that these same agencies, together with undermining work applied for wilful destruction, could do what has been done."[2] The plentiful supply of saltpetre to be found in the valley of the Ganges has been brought forward as a proof that the ancient Hindus must have had gunpowder, but the fact proves nothing. How many centuries did coal lie within reach of man's hand, in England and elsewhere, before it was discovered and made use of? The attractive property of the magnet was known to Plato in the fifth century B.C., and Lucretius in the first century B.C. devotes a long passage of his poem to it (vi. 909–1089); yet its property of pointing north and south when free to move horizontally is first distinctly mentioned (in Europe) in the twelfth century A.D.[3]

[1] *Journal of Asiatic Society of Bengal*, xvii. 244.

[2] General Maclagan on "Early Asiatic Fire Weapons," ib., xlv. 64.

[3] Among other books, the *De Naturis Rerum* of Nekham, 1157–1217, Rolls Series, p. 183.

The editor, Mr. Thomas Wright, remarks in his preface, xxxv. :— "The mariner's compass, in a rude form, was in use among the sailors

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Early Indian gunpowder is a fiction.

The first gunpowder and firearms used in India were neither invented nor manufactured by the Hindus: they were imported during the Middle Ages from the West. The guns of Upper India entered through Afghanistan; those of Western India were brought by ships. Let us consider the latter first.

"If any reliance is to be placed on Moulla Daud Bidury, the author of *Tohfutu-s Salutin*," says General Briggs, "guns were used (in 1368) by the Hindus (of Bijanagar), and in a subsequent passage (Ferishta remarks) that the Muhammadans used them for the first time during the next campaign. But I am disposed to doubt the validity

in Western Europe at an early period, and . . . instead of being borrowed from the East, as is generally supposed, it seems to have been invented in this part of the world. Of course I do not mean to say that it was not invented in other parts also." It is explicitly noticed in a Chinese Encyclopædia finished in A.D. 121 (Sir J. Davis, "The Chinese," &c., ii. 185). But Chinese chronology is always suspicious, and, even if this date be correct, there is no evidence to show that the invention ever reached the West. The Chinese seem to have guarded their discoveries and inventions with a jealous eye. Their valuable and accurate astronomical observations were only laid open to Europe by the Jesuits, more than two thousand years after they were made. The printing press was not invented in Europe until the fifteenth century, yet Feng Tao had invented block-printing in China in the tenth (Giles' "Chinese Literature," p. 210). According to their own account, the Chinese have used tea since the year 2737 B.C. It was not heard of in Europe until after A.D. 1517, and did not become generally known until the seventeenth century. Brunetto Latini (1230–94), quoted by Davis, gives a curious, but only too probable a reason for the slow progress of the compass in Christendom: "No master mariner dares to use (it), lest he should fall under the suspicion of being a magician."

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of both these statements . . . Ferishta . . . also observes that Turks and Europeans skilled in gunnery worked the artillery. That guns were in common use before the arrival of the Portuguese in India in 1498, seems certain from the mention of Faria y Sousa."[1]

The first observation suggested by this passage is, that Ferishta does not say the Hindus had *guns* on this occasion; he says they had عرابه (*'arábah*),[2] a word which originally meant a *cart*. In the early days of field artillery the guns were carried in carts,[3] from which they were taken and laid on trestles when required for use. Wheeled gun-carriages only came into general use in Europe during the reign of Louis XI. of France (1461–83).[4] Things followed the same course in India, and the word 'arába thus came in time to have two meanings; most 'arába being simply carts, some being (so to speak) gun-carriages. Then later writers arose who insisted that all 'arába were gun-carriages at the early date of 1368, because *some* 'arába were gun-

[1] Ferishta, "Hist. of the Rise of Mahomedan Power," &c., trans. by General J. Briggs, 1829, ii. 312.

[2] See Prof. Dowson's note in Elliot, iv. 268.

[3] Grose gives two plates of these "Ancient Gun Carts" in his "Military Antiquities," i. 407. They are mentioned in the Acts of the Scotch Parliament, 52 of James II. and 55 of James III.

[4] Favé, *Hist. et Tact. des Trois Armes*, p. 12. Grewenitz, *Traité de l'Organ., &c., de l'Artillerie*, p. 28. Wheeled gun-carriages were so little known to the general public as late as 1548, that Rabelais specially mentions some "pieces d'Artillerie sus roue" in his account of a sham fight at Rome in this year. "La Sciomachie," in his works, ed. by Burgaud des Marets and Rathery, ii. 568.

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carriages in and after 1526. Ferishta (who died about 1611) fell into the trap, and after him fell several modern historians.

Secondly, General Briggs' conclusion about guns in India before 1498 seems somewhat unguarded. It is beyond dispute that firearms were used on the west coast of India during the last quarter of the fifteenth century, but the evidence we possess points to the conclusion that they belonged almost exclusively to Arab and Portuguese ships. The fact that Captain Cook cruised on the coast of Otaheite in 1769 in a ship equipped with firearms, does not warrant the conclusion that the natives possessed firearms. Ferishta was writing about events which took place two hundred years before he was born, and there is a particular reason for doubting the existence of firearms in Bijanagar at this early period.

In 1441 'Abd ur-Razzak, who had been sent to India by Shah Rukh on an embassy to Calicut, visited Bijanagar, whose ruins may still be seen on the banks of the Tumbhadra. He has given us a full and amusing account of what he saw, bursting forth into poetry on the ugliness of the natives :—

> "I have loved a moon-faced beauty,
> But I cannot fall in love with every black woman."[1]

He was present at the great review held during the festival of Mahanawi, when "the number of people and the huge elephants resembled the green sea and the myriads which will appear on the Plains

[1] Elliot, iv. 100.

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of the Resurrection." Not an allusion is made to firearms, although he notices the naphtha-throwers mounted on elephants.[1]

Ferishta tells us that in the year 887 A.H. (A.D. 1482), Mahmoud Shah Begurra of Gujarat, hearing that Cambay was likely to be raided by the pirates of Bulsar, collected a fleet containing "a force of gunners, musketeers, and archers," and defeated them. On this passage General Briggs remarks: "This is the first mention of artillery and musketry in the Gujarat history. They were probably introduced by the Arabs and Turks from the Red Sea and Persian Gulf."[2] The firearms that came from the Persian Gulf must have been few and far between. Writing in 1549, a Jesuit says: "The Persians use no bombards or arms of this kind."[3]

There is no mention of the Bulsar expedition in the "History of Gujarat," by Ali Muhammad Khan, translated by Mr. J. Bird.

The *Mirat-i Sikandari*, a history of Gujarat translated by Sir E. C. Bayley, speaks of an attack made by Mahmoud on certain pirates as early as 878 A.H. (A.D. 1473), but neither Bulsar nor firearms are mentioned. We are told, however, that during a previous expedition in the same year against the island of Sankhodhar, the infidels (Hindus) "re-

[1] Elliot, iv. 117.

[2] iv. 65.

[3] "Nullis bombardis nec aliis hujus generis tormentis utuntur." *Epist. Indicæ*, M. Gaspari Belgæ, p. 38

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sisted bravely and kept up a sustained discharge of arrows and muskets" (pp. 198–9).

Ferishta relates that during the siege of Champanir, 1484, a shell (*hookah*) fell on the Rajah's palace; but he does not state how it was discharged, nor whether it was explosive or incendiary.[1]

On landing at Calicut in 1498, Vasco da Gama and his followers were led through the streets with tomtoms beating, and from time to time an *espingarda*, or musket, was fired off.[2] The town seems to have possessed only one of these weapons. At least, the soldiers of the guard who mounted over Gama after he had been arrested were not armed with espingardas, but with swords, daggers, and bows,[3] and no mention is made of there being any cannon in the town.

In 1502 a sea-fight took place in these waters between a Portuguese man-of-war and a Moorish (Arab) ship, during which the Arab bore down on the Portuguese, "pouring in her shot, and then made away."[4] The original says: "Una nube de flechas sobre nuestra gente y algunas balas;" *i.e.* a

[1] iv. 69.

[2] "Hũa espingarda a qual hia tirando amte nos." Roteiro da Viagem, &c., 1838, p. 57. Trans. in Charton, *Voyageurs Anciens*, &c., iii. 247.

[3] "Tous armés d'épées, de guisarmes, d'écus, d'arcs et de fléches." Charton, ib., 252. Guisarmes, which I have translated by "daggers," is a word of obscure origin, but it means some small *arme de main*. We find in Ducange, under *gisarma*, "cultellos et alia arma minuta." Diez, *Etymologisches Wörterbuch*, ii. 217, *giusarma*.

[4] Faria y Sousa, trans. by Capt. J. Stephens, 1695, i. 58.

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cloud of arrows and some balls.[1] These balls were undoubtedly cannon balls.

It is stated in MSS. 826–8, *Bib. Nat.*, Paris, that in 917 A.H. (A.D. 1511–12) Modhaffer Shah of Gujarat sent to Kansuh, King of Egypt, asking him for arms and cannon to enable the Gujaratis to defend themselves against the Europeans; "the people of India not having hitherto possessed Artillery of any kind."[2] In answer to this request, Hossain was sent to sea in command of a considerable fleet. If Mahmoud possessed ships with guns in 1482, how came it that in 1511 the Gujaratis were sending round the world begging for firearms? Had Mahmoud merely hired for the occasion from the Arabs the ships and guns with which he crushed the Bulsar pirates? It is impossible to say categorically; but two facts may be extracted from the foregoing conflicting statements—first, that firearms were used by Arab and Portuguese ships on the west coast of India before the Hindus possessed them, and secondly, that there was an espingarda in the town of Calicut in 1498.

Whatever doubt there may be about the exact date at which the natives of Western India first

[1] Faria y Sousa, *Asia Portuguesa*, i. 48.

[2] "Car les peuples de l'Inde n'avaient en jusque là ni canons ni autres pièce d'Artillerie—مدافع صكاحل وبندقيات." *La Foudre du Yemen*, trans. by S. de Sacy in *Notices et Extraits des MSS. de l'Acad. des Inscriptions, &c.*, iv. 420. For *mukáhal*, see Hyde's *Syntagma Dissertationum*, 1767, ii. 128. Prof. S. Lane-Poole gives the date as 1508; "Mediæval India," p. 176.

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procured firearms from the foreign ships which visited their shores, there can be none about the first employment of artillery in Upper India.

As has been already stated, the machines of the Greeks were adopted at an early period by the Persians, from whom they were eventually borrowed by the Arabs, Mughals, &c. The Hindus in turn adopted the machines they saw employed by their invaders and named them, according to their custom, after the part of the world they came from—*maghribíha = western* (machines or manjaník). At the abortive attack on Rantambhor, 1290, Sultan Jalalu-d Din ordered Westerns to be erected.[1] The Hindus had collected materials for making incendiaries before being besieged in the same fortress by Sultan Alau-d Din in 1300. "Every day the fire of those infernals fell on the light of the Moslems, and, as there were no means of extinguishing it, they filled bags with clay and prepared entrenchments. . . . The Royal Westerns shot large earthen balls against that infidel fort. . . . The stones from the ballistas and catapults within and without the fort encountered each other half-way and emitted lightening."[2] During the attack on Arangal, 1309, the Westerns "were played on both sides and many were wounded."[3] The mud walls were so strong and elastic that the balls of the Westerns rebounded off them "like

[1] Ziau-d Din Barni, in Elliot, iii. 146.
[2] Amir Khusru, ib., 75.
[3] Barni, ib., 202.

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nuts which children play with."[1] Eventually the "western stone-balls" formed a breach and the fort fell. Such is the account given by Amir Khusru who died in 1315, of whom Sir H. M. Elliot says (vi. 465):—"He is full of illustrations and leaves no manner of doubt that nothing like gunpowder was known to him." Near the close of the century, 1398–9, the Hindus besieged by Timur in Bhatnir "cast down in showers arrows and stones and fire-works upon the heads of the assailants."[2] At the attack on Chanderi, 1527–8, "the Pagans exerted themselves to the utmost, hurling down stones and throwing flaming substances on the heads" of Babar's troops.[3] In 1528–9, the Hindus succeeded in igniting with "fireworks, turpentine, and other combustibles" some hay which the Mughals had collected in the fort of Lucknow. The heat became so intolerable that the Mughals retired and the fort was taken.[4]

It is needless to enlarge the list of quotations: incendiaries pursued much the same course in Upper India as in Greece and Arabia. No reliable evidence of an explosive is to be found until the 21st April 1526, the date of the decisive battle of Panipat, in which Ibrahim, Sultan of Delhi, was killed and his army routed by Babar, the Mughal, who possessed firearms great and small.[5]

On the introduction of Artillery the word

[1] Khusru, ib., 80. [2] "Malfuzat-i Timuri," ib., 424.
[3] "Tuzak-i Babari," ib., iv. 276. [4] Ib., 286.
[5] Ib., 251 *ff.*

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maghribiha was gradually replaced by the more definite word *feringiha* = European. At Panipat the Artillery of the left centre was commanded by Mustapha Rumi, whose name is sufficient proof of his western origin. But traces of European artisans are to be found long before this. When the King of Gor crossed the Attok in the twelfth century, he had with him "skilful Franks, learned in all the arts."[1] The success of the attack on Chitor in 1591, by Buhadur, Sultan of Gujarat, was chiefly due to his engineer, Labri Khan of Frengan = Frangistan, the country of the Franks.[2] Speaking of the Mughal Artillery in 1695, Dr. Careri tells us that it was "all, especially the heavy Artillery, under the direction of Franks, or Christian gunners, who had extraordinary pay."[3]

Haidar Mirza gives us one or two details about Babar's guns which deserve a passing notice.[4] There

[1] Suraj Prakas, in Col. Tod's "Annals of Rajast'han," ii. 8.

[2] Ib., i. 310.

[3] Dr. Careri in Churchill's "Collection of Voyages," 1744, iv. 237.

[4] Elliot, v. 131–2. Babar's ironical description of the Bengalis as gunners is taken quite seriously by some writers: "The Bengalis are famous for their skill in Artillery. . . . They do not direct their fire against a particular point, but discharge at random," Elliot, iv. 285. Such a procedure is not altogether unknown in Europe. When shooting, Mr. Tracy Tupman was wont to shut his eyes firmly and fire in the air.

Were these gunners friendly Bengalis employed by Babar, or hostile Bengalis working their own guns? If the latter, their guns were probably made by Portuguese deserters. We know that two artisans deserted in 1503 to the Zamorin of Calicut, for whom they offered to make guns of the same nature as the Portuguese, "which they afterwards did." Castenheda in Kerr's "Collection of Voyages," ii. 454, quoted in Elliot, vi. 467.

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was a *zarb-zan*, or swivel gun, carrying a ball of 500 *miskals*, and a heavier gun throwing a "brass" ball which weighed 5000 *miskals*, and cost 200 *miskals* of silver. The former was drawn by four, the latter by eight pairs of bullocks. Let us adopt the weight of the *miskal* given in Steingass' "Persian Dictionary,"—1⅞ drachms = 39.045 grs. troy, which makes the weight of Babar's large ball 34 lbs. nearly.[1] Its price, 200 *miskals*, would then be 7809 grs. troy of pure (silver), or (since our standard shilling is 87.27 grs. troy and its fineness $\frac{37}{40}$) 96.7 shillings of our present money. The price of a 10.18 lbs. ball of the same material would consequently be 29s., including the cost of manufacture. The price of the English 4″ bronze ball of 10.18 lbs. given here in Table X., is 26.468d., or about 22s. of our present money, exclusive of the cost of manufacture. Adding 7s. to cover the cost of manufacture,[2] its price would be about 29s. The value of the alloy in our shilling has been neglected here, and Queen Elizabeth's money may not have been worth exactly seven times our money; but making full allowance for both these errors, the prices of the two balls approximate as closely as can be reasonably expected.

Gunpowder was not invented by the Hindus:

[1] The 71 grs. avoir. given to the *miskal* by Burton and Clarke ("Persian Handbook") would make Babar's large shot weigh 50 lbs.—an impossible weight, as every officer will admit who remembers our 18 Pr. S.B. bullock batteries in India. Babar could not have dragged 50 Prs. from Caubul to Panipat. Burton admits that the miskal "varies everywhere." "Arab. Nights," 1894, vii. 324.

[2] *i.e.* two men's wages for one day. See p. 205.

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its discovery by them would have fallen little short of a miracle. The extinction of Buddhism about the ninth century A.D., and the consequent establishment of a dominant priestly class, were a death-blow to the cultivation of physical science. By the seemingly innocent institution of *caste*, the Brahmins succeeded in trampling science in the dust. One caste was not permitted to touch this, another caste could not touch that substance; and the higher the caste, the greater the number of forbidden objects. The study of experimental science was consequently thrown back upon the lowest and poorest classes, who had neither the means, the leisure, nor the inclination to pursue it. Thus "the spirit of inquiry gradually died out," says a Hindu Professor of Chemistry, "and the name of India was all but expunged from the map of the scientific world."[1]

[1] "Hindu Chemistry," pp. 107–8.

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CHAPTER VII

THE CHINESE

CHINA, like India, affords an example of "arrested civilisation:" the Chinese intellect and language became petrified while still in a primitive stage of development. But, unlike the Hindus, the Chinese betook themselves at an early period to historical pursuits. "Debarred both by the nature of the material at their command and by a lack of original genius from indulging in the higher branches of imaginative writing, Chinese authors devoted themselves with untiring energy and with very considerable ability to the compilation of information concerning their own and neighbouring countries."[1] Among the results of their labours are the "Twenty-One Histories," from the third century B.C. to the middle of the seventeenth century, sixty-six folio volumes, and a number of vast Encyclopædias, of which the *Koo-kin-too-shoo*, &c., occupies 6109 volumes. From such immense compilations and other sources Chinese scholars have supplied us with much information about the present subject.

Although the invention of gunpowder is disclaimed for his countrymen "by every (Chinese)

[1] Prof. R. K. Douglas, "China," in *Ency. Brit.*, v. 663.

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writer who treats seriously" on the subject,[1] the people cherish the legend that the invention was made by a Chinaman in some forgotten past. The existence of this legend among a people possessed of a deep veneration for antiquity is in no way surprising. Every Chinese custom, art, and institution is supposed to be very ancient, and what is not really old is readily invested with fictitious antiquity. The world as we know it, they tell us, came into being 2,670,000 years before Confucius, who was a contemporary of the prophet Daniel. "The more sober historians, however, are content to begin with a sufficiently mythical Emperor, who reigned only 2800 years before the Christian era."[2] This insatiable craving for antiquity is shown in all their works. "As with all other arts (the Chinese) have claimed for the manufacture of porcelain an antiquity far beyond the actual facts of the case. This exaggerated estimate of the antiquity of Chinese porcelain was for a long time supported by the supposed discovery in Egypt of certain small bottles made of real porcelain and inscribed with Chinese characters, which were said to have been found in tombs at Thebes, dating as early as 1800 B.C. The fact, however, that they are inscribed with quotations from Chinese poets of the eighth century A.D., and have characters of a comparatively modern form, shows

[1] "Gunpowder . . . among the Chinese," in *Journal of North China Branch of Roy. Asiatic Soc.*, N.S. vi., 1869-70, p. 74, by W. F. Mayers, F.R.A.S., Chinese Consular Service. "Gunpowder came from the outer barbarians," says the *Wuh-li-siao*, published in 1630.

[2] Prof. H. A. Giles, "Hist. of Chinese Literature," 1901, p. 4.

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that the whole story of their discovery is a fraud. . . . During all periods Chinese potters were constantly in the habit of copying earlier styles and of forging their marks, so that very little reliance can be placed on internal evidence. Indeed, the forgeries often deceive the Chinese collectors of old porcelain."[1]

According to the Jesuits, Chinese history is free from this defect. Father Moyria de Maillac (commonly called Mailla), in the long introductions to his *Histoire générale de la Chine*, begs us to put our full trust in the Chinese historians, and pleads that, however mendacious the lower orders of the nation, the better classes love the truth, and the historians are honest and accurate. But such pleas in bar of investigation and verification are of little weight unless it can be shown that Chinese historians never drew (in good faith) erroneous conclusions, never mistook the meaning of a document, were never misinformed, and never made a slip in writing. As Gibbon clearly saw,[2] the Jesuits were blinded by admiration of the Celestials; their sharp, critical sagacity was blunted by the air of sincerity displayed in Chinese books.[3] But this "accent de sincérité" is ruthlessly treated by MM. Langlois

[1] Mr. J. H. Middleton, "Pottery," in *Ency. Brit.*, xix. 633.

[2] "Decline and Fall," &c., iv. 231 *n* (Bury's ed.).

[3] The Jesuits, "either seduced by some appearance of truth, or thinking it prudent to conciliate the people whom they were attempting to convert, adopted their marvellous relations regarding the antiquity of their science, and spread them over Europe."—Mr. R. A. Proctor, "Astronomy," *Ency. Brit.*, ii. 746.

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and Seignobos: "C'est une impression presque irrésistible, mais elle n'en est pas moins une illusion. Il n'y a aucun critérium extérieur ni de la sincérité ni de l'exactitude. 'L'accent de sincérité,' c'est l'apparence de la conviction; un orateur, un acteur, un menteur d'habitude l'auront plus facilement en mentant qu'un homme indécis en disant ce qu'il croit. La vigeur de l'affirmation ne prouve pas toujours la vigeur de la conviction, mais seulement l'habileté ou l'effronterie. De même l'abondance et la précision des détails, bien qu'elles fassent une vive impression sur les lecteurs inexpérimentés, ne garantissent pas l'exactitude des faits;[1] elles ne renseignent que sur l'imagination de l'auteur quand il est sincère ou sur son impudence quand il ne l'est pas. On est porté de dire d'un récit circonstancié: 'Des choses de ce genre ne s'inventent pas.' Elles ne s'inventent pas, mais elles se transportent très facilement d'un personage, d'un pays ou d'un temps à un autre.—Aucun caractère extérieur d'un document ne dispense donc d'en faire la critique."[2] In spite of their zeal for the truth, Chinese historians are no more infallible than others, and it is certain that they were unconsciously led into error at times by the change in meaning which military words underwent in China as well as elsewhere. Thus

[1] "Un bon exemple de la fascination exercée par un récit circonstancié est la légende des origines de la Ligue des trois cantons suisses primitifs (Gessler et les conjurés du Grütli) *fabriquée* au XVI^e^. siècle par Tschudi, devenue classique depuis le 'Guillaume Tell' de Schiller, et qu'on a eu tant de peine à extirper."

[2] *Introd. aux Études Historiques*, pp. 136–7.

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Mao-yiian-i erroneously believed that *huo-p'áu* meant *cannon* in old times, as it did in his own. But from a sketch he has fortunately given of one (reproduced by Romocki, i. 41) it is clear that it originally meant a machine for scattering blazing incendiary matter.

The first two questions that present themselves are: (1) Did the Chinese make use of gunpowder in a very distant past? and (2) did they possess an explosive shell in 1232?

The Chinese annals give no support to the hypothesis that gunpowder was known in China in very early times. Currency was given to the popular legends about it by such writers as Father Gaubil, who declares that gunpowder had been in use for 1600 years when he wrote, and Father Amiot, who fully accepts a much earlier date. With reference to Koung-ming, who is said to have employed earth-thunder (*ty-lei*) about 200 A.D., Amiot says: (*a*) "Les auteurs qui parlent de Koung-ming ne le font pas l'inventeur de cette manière de nuire à l'ennemi. Ils disent, au contraire, qu'il l'avait puisée dans les ouvrages des anciens guerriers; ce qui est une preuve sans réplique que les Chinois connaissaient la poudre à tirer . . . bien longtemps avant que cette connaissance fût parvenue en Europe. . . . (*b*) Les anciens Chinois employaient la poudre (*chen-ho-yen*), soit dans les combats, soit pour mettre le feu au camp des ennemis. . . . (*c*) Cette poudre (*ny-foung-yo*) a une vertue qui, ce me semble, pourrait être d'une tres grande utileté dans nos armées; c'est que la

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fumée va également contre le vent."[1] In (*a*) and (*c*) of these extracts the true note of legend is audibly sounded, and the tacit assumption that *ty-lei* was an explosive is to be noted. As to (*b*), Amiot was unwittingly describing some early incendiary similar to that of Marcus Græcus, No. 2: "Ignis quæ comburit domos inimicorum." Such is Father Amiot's "preuve sans réplique" that the Chinese possessed gunpowder in the times of the pre-adamite Sultans. It must be put aside; and with it must be laid the evidence of Fathers Maillac and Gaubil. First, their critical faculty became paralysed when dealing with Chinese history. Secondly, they evidently did not understand the difference between an explosive and an incendiary. Thirdly, without questioning their good faith, they are open to the charges brought against them by MM. Reinaud and Favé, when speaking of M. Quatremère's dating Artillery in China at the thirteenth century: "(Il) ne s'est pas aperçu que PP. Mailla et Gaubil avaient traduits différement certains passages des Annales chinoises, et qu'ils y avaient même ajouté tantôt des expressions de leur cru, et tantôt des interpolations de la version tartare-mandchou, version qui date seulement d'un peu plus d'un siècle, et qui, par conséquent, n'a aucune autorité."[2]

Had the Chinese an explosive shell in 1232?

The following is a translation by M. Stanislas Julien of a passage in the Encyclopædia entitled

[1] *Mémoires concernant l'Hist., &c., des Chinois*, viii. 336.

[2] In *Journal Asiatique*, Oct. 1849, p. 258.

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T'ung-Chien-Kang-Mu, relating to the siege of Pien-king (now Kai-fung-fu) in 1232, given by Reinaud and Favé in the *Journal Asiatique*, Oct. 1849 : "A cette époque on faisait usage de *ho-pao* ou *pao à feu*, appelée *Tchin-tien-loui*, ou 'tonnerre qui ébranle le ciel.' On se servait pour cela d'un pot en fer que l'on remplissait de *yo*. A peine y avait-on mis le feu que le pao s'élevait, et que le feu éclatait de toute part. Son bruit ressemblait à celui du tonnerre, et s'étendait à plus de cent *lis* (*i.e.* thirty-three English miles); il pouvait répandre l'incendie sur une surface de plus d'un demi-arpent (*i.e.* about one-third of an acre). . . . Les Mongols construisirent avec les peaux de bœuf un couloir qui leur permit d'arriver jusqu'an pied des remparts. Ils se mirent à saper les murs, et y practiquèrent des cavités, où l'on pouvait se loger sans avoir rien à craindre des hommes placés en haut. Un des assiégés proposa de suspendre à des chaînes de fer des pao à feu, et de les descendre le long du mur. Arrivés aux endroits qui étaient minés, les pao éclataient et mettaient en pièces les ennemis et les peaux de bœuf, au point même de ne pas en laisser de vestige." There is another account of the shell in the *Wu-pei-chi*, published in 1621, but (as one gathers from Mr. Mayers[1]) it is so similar in the details that the two accounts cannot be taken as independent. They merely quote some common document or repeat some common tradition.

Like the *Liber Ignium* of Marcus Græcus, the

[1] In *Journal Asiatique*, Oct. 1849, p. 91.

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T'ung-Chien-Kang-Mu is not the work of one man or of one period. The original portions (the "Old Recipes" of Marcus) were written by Ssu-ma-kuang, 1019–86, and were named *T'ung-Chien*, or the "Mirror of History," by the reigning Emperor. The book was brought up to date by Chu-hsi, 1130–1200, and was afterwards continued, with commentaries, by various writers, up to the seventeenth century. The above-quoted passage belongs to the commentators,[1] and was written by some one whose date, name, and authority for his statement are alike unknown to us; but it was presumably written long after the event it records.

We have seen in Julien's translation what the encyclopædist actually says, but what meaning did he intend to convey by his words? Did he mean to say the shell exploded? The passage may be divided into two clauses: in the first he explains generally the action of the ho-pao, and in the second he gives a particular example of its use. In the first clause he says that "no sooner was a light applied to it than the fire burst forth on all sides" (*le feu éclatait de toute part*): in the second clause he says, "the pao burst forth" (*les pao éclataient*). But the effect produced by the shell shows that this latter phrase is simply an elliptical way of saying, "the fire of the mixture contained in the pao burst forth." On this point Reinaud and Favé are clear: "*Les pao à feu éclataient* s'applique aux éclats de la flamme qui

[1] Reinaud and Favé, in *Journal Asiatique*, Oct. 1849, p. 284 *n.*

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sortait par les ouvertures,"[1]—holes in the shell which were probably numerous. Mayers agrees: the pao were lowered into the excavations, "when the fire burst out from them, utterly destroying every fragment of the hides," &c.[2] The Chinese writer was describing an incendiary, not an explosive. Gunpowder would have left in the hiding-place of the Mongols a tangled mass of charred human remains and scorched cowhide: only an incendiary could have destroyed its contents so that "not a vestige remained." Father Gaubil and M. Berthelot acquiesce in this conclusion:[3] Herr von Romocki dissents from it.[4]

There is nothing in the military history of China in the thirteenth and fourteenth centuries to lead us to suppose that the Chinese possessed an explosive during that period. In 1255 Prince Hulágu had 1000 Chinese arbalisters in his pay to work his incendiaries,[5] and it may be presumed that he would have learnt the secret of gunpowder from them if they had known it; but he possessed no explosive. Father Carpini, *cir.* 1250, states that when hard-pressed the Tartars had recourse to incendiaries, and Rashid ed-Din, in his history of Hulagu's campaign of 1260, makes no allusion to explosives.[6] The Chinese had only reached the same stage as Marcus Græcus in 1257: in this year they had

[1] Reinaud and Favé, in *Journal Asiatique*, Oct. 1849, p. 291.
[2] As before, p. 91.
[3] *Sur la Force des Matières Explosives*, ii. 354. [4] i. 48.
[5] Howorth's "Hist. of the Mongols," iii. 97.
[6] Reinaud and Favé, in *Journal Asiatique*, Oct. 1849, pp. 296, 308.

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Roman candles.[1] During the siege of Siang-yang-fu, 1268–73, "Khubelai sent to his nephew Abaka, in Persia, for engineers skilled in making catapults, called mangonals[2] by Marco Polo. Two such engineers were sent."[3] We have three different notices of this siege, Chinese, Persian, and Venetian, and "they all concur as to the employment of foreign engineers from the West,"[4] but none of them mentions the use of explosives by either side. "The Chinese at that period," says Sir John Davis, "were as little acquainted with firearms as Europeans."[5] When Chang-chi-ki's fleet on the Kiang River was destroyed a few years afterwards by Atchu, it was by means of fire-arrows.[6] In a word, during the thirteenth century, the Chinese made a free use of various incendiaries already noticed in the chapters on the Greeks and Arabs; and they seem to have made no progress in the manufacture of their missiles during the course of the fourteenth.[7] Not until we reach the fifteenth century do we meet with gunpowder and cannon.

The Prince of Yen (afterwards the Emperor Yung Loh) is said to have been "defeated by fire-

[1] Romocki, i. 51.

[2] This word, which Diez (*Etymolog. Wörterbuch*) derives from *μάγγανον*, betrays the western origin of the machine. It was well known in England :—

> "Set Mahound at the mangonel, and millstones throw."
> —"Piers Plowman," C text, *cir.* 1393, passus xxi.

[3] Howorth, i. 125.

[4] Yule, in "Marco Polo," ii. 152.

[5] "The Chinese," &c., ii. 181.

[6] Howorth, i. 129.

[7] Mayers, p. 93.

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arms" at the battle of Tung Chang, 1401;[1] but whether these arms were furnished with incendiaries or explosives is doubtful. The first trustworthy account of the use of artillery in China is given in the *Kai-yii-tsung-kao*, published in 1790, by Chao I, a man of considerable ability, and an accomplished antiquarian. He states that in the beginning of Yung Loh's reign, 1407, cannon were acquired by the Emperor and employed during his campaigns in Cochin China.[2] Whence came these cannon and their ammunition?

It is antecedently improbable that the Chinese either invented or manufactured them; for although the Chinese exhibited considerable intellectual power in some fields of investigation, they possessed little genius for mechanical or chemical inventions, and what mechanical ability they had was absorbed in other pursuits. When actually possessed of powder, they seem to have been incapable of making any improvement in its manufacture. "Si la poudre de Chine vaut mieux que la nôtre," says Father Incarville, the ablest of the Jesuits I have consulted, "cela vien plutôt de la bonté des matières que du soin que les Chinois prennent de la faire bonne; ils la grainent très mal et ne savent pas la lisser."[3] "Whatever their claims as inventors," says another writer, "it is certain that the Chinese have made no progress in the art" (of making gunpowder).[4] Even

[1] Mayers, p. 93.
[2] Ib., 94-5.
[3] Reinaud and Favé, p. 254.
[4] *Ency. Metropol.*, art. "China," p. 593.

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their fireworks were no better than European fireworks. They did not employ stars, and their largest rockets had a length of only five inches, with an internal diameter of eight lines.[1]

There is no trustworthy evidence, so far as I am aware, to prove that the Chinese invented gunpowder. The statements of the Jesuits on this particular matter are worthless for reasons already given,[2] and the popular Chinese tradition is deprived of any little weight it might otherwise have had by the disavowal of the invention by sober Chinese historians. On the other hand, we possess a number of facts which point to the conclusion that the Chinese obtained their first gunpowder and firearms from the West.

(*a*) It has been already pointed out that the mangonals used at the siege of Siang-yang-fu, 1268–73, were of western origin, and were worked by western engineers.

(*b*) The residence of the Polos in China, 1275–92, was by no means an isolated fact. They were but the pioneers of a considerable body of mechanics, missionaries, and merchants who continued their relations with

[1] Incarville, in Reinaud and Favé, p. 259.

[2] These Fathers were strangers to the "doute méthodique" of MM. Langlois and Seignobos, and they certainly did not scan the pages of their vast Chinese Encyclopædias with the doubting eye of Heine:—

"Augen gab uns Gott ein Paar,
Dass wir schauen rein und klar;
Um zu glauben was wir lesen,
Wär' ein Auge gnug gewesen."

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the country for at least half a century.[1] It may be doubted whether the merchants ever lost touch with China.

(*c*) Yung Loh, the first Chinese Emperor who possessed *ts'iang*, or cannon, had agents in Malay, Delhi, Herat, and Mecca,[2] and his agent in the latter city could hardly have failed to hear of, and report on the use of firearms in the West. If such were the case, there was nothing to prevent the Emperor from obtaining small guns by land, or guns of any size by sea. There had been communication by land between China and Europe from the time of the early Roman emperors of the West.[3] It was seriously interrupted, no doubt, by the disorders which broke out in China at the close of the ninth century, but it was re-established when they came to an end in the middle of the thirteenth.[4] Mr. F. Hirth proves in his "China and the Roman Orient" that there was communication by sea between China and Europe at a very early date. Masudi speaks of the communication in his own time, the tenth century. The Arab and Chinese ships met, he says, at a port called Killat, half-way between Arabia and China, where they transhipped their

[1] Sir Henry Yule, in *Ency. Brit.*, v. 628. [2] Mayers, p. 95.
[3] Gibbon, iv. 230, and Appendix 12, by Dr. Bury.
[4] Reinaud and Favé, p. 201 *n.*

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cargoes.[1] There was constant communication between China and the west coast of India in the first half of the fifteenth century. Abd ur-Razzak says the men of Calicut were bold navigators, and adds that they were called (in compliment) "the sons of China." When John Deza destroyed the Zamorin's fleet there, it was commanded by a Chinaman, Cutiale.[2]

(*d*) The Chinese made their charcoal from young shoots of the willow in the eighteenth century,[3] and "as they seldom change anything,"[4] they probably did so from the beginning. Twigs of willow are recommended for this purpose by Roger Bacon and Hassan er-Rammah (pp. 149, 24).

(*e*) The Chinese strained the mother-liquor of their saltpetre through straw;[5] so also did Whitehorne (A., p. 20).

(*f*) They employed animal glue, or charcoal, to remove the insoluble impurities of the mother-liquor,[6] just as Bacon did, if the explanation of the word "Phœnix" given in Chap. VIII. be accepted (p. 154).

(*g*) They incorporated the ingredients of gun-

[1] "Golden Prairies," Paris ed., i. 308.

[2] Elliot, iv. 103.

[3] Incarville, in Reinaud and Favé, p. 254.

[4] Sir J. Davis, "The Chinese," &c., ii. 182. "Ils ne sont point envieux de rien faire de nouveau," Incarville, as above, p. 259.

[5] Incarville, as above, p. 252. [6] Ib.

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powder on a *marble* slab,[1] as directed by Marcus Græcus, recipes 4 and 13, for incendiaries, and by Arderne for gunpowder (p. 177).

(*h*) They passed their rocket composition through a sieve of fine silk,[2] the counterpart of Arderne's "sotille couerchief" (Ib.).

(*i*) They occasionally added camphor and mercury to their powder,[3] like Kyeser and many other westerns (Romocki, i. 157).

(*j*) They called their powder *yo*, "the drug," as did the Germans, Danes, and Dutch (p. 6).

(*k*) They used varnishes,[4] of the same family as the *lutum sapientiæ*, Marcus Græcus, recipe 1.

(*l*) An Encyclopædia, quoted in the *Pai-pien*, 1581, states that "on the walls of Si-ngan there was long preserved an iron *chen-tien-lui* = heaven-shaking thunderer, which in shape was like two cups"[5]—the shell of Valturio (p. 221).

(*m*) Bits of metal, *mitraille*, were added to the charge of Chinese shells,[6] after the manner prescribed in a German Firebook (Romocki, i. 189).

(*n*) The shell were loaded with the *maximum* charge that could be rammed into them,[7] as directed in the same Firebook (ib.).

[1] Father Amiot, in Reinaud and Favé, p. 181.
[2] Incarville, as above, p. 247.
[3] Amiot as above.
[4] Ib.
[5] Mayers, as before, p. 91.
[6] Amiot, as before, p. 183.
[7] Ib.

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(*o*) For repairing and closing the interstices of their built-up bombards, the Chinese appear to have used the same materials the Scotch used for Mons Meg; and it is noticeable that the Chinese preferred "western iron" for this purpose: "Ils emploient pour les confectionner du cuivre rouge. Dans les interstices apparents, ceux qui emploient du fer se servent de fer doux et malléable pour consolider (ces machines). Le fer de l'Occident est le meilleur qui puisse être employé à cet usage."[1] In the "Chronicles and Memorials of Scotland," vol. vi., for July 1459, we find: "For the repair of the great bombard at Edinburgh, brass, copper and iron, *so much*" [*pro expensis factis circa eandem emendacionem* (*magni bumbardi ante castellum de Edinburgh*) *in ere, cupro et ferro*].

(*p*) In 1520 the heavy guns of the Portuguese ships at Canton "attracted considerable attention, and soon acquired the name of 'Franks.' . . . The Chinese seem to have subsequently availed themselves of the assistance of the Portuguese, and of their wonderful guns, to punish their own pirates";[2] a circumstance which recalls the expedition of Mahmoud of Gujarat

[1] *Hoang-chao-li-ki-thou-chi*, trans. by Pauthier in his edition of "Marco Polo," p. 475 *n*.

[2] E. H. Parker, "China," &c., 1901, p. 83.

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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.).

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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.

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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.

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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.

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> 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.

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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

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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

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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.*

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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."

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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.

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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.

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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.

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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.

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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 brouïllez 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.

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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.

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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:—

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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*.

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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$\frac{2}{7}$ 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*.

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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.

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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

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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.

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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.

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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.

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PART II

THE PROGRESS OF AMMUNITION

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CHAPTER IX

ANALYTICAL TABLE OF AMMUNITION

To those who are not professional gunners, Artillery ammunition may seem at the first glance to be a hopeless and chaotic jumble of endless stores. This is no doubt partly owing to the necessary multiplicity of the stores, but far more to the absence (in most books and lists) of any synoptic digest, or plan, showing at one view the classification of the whole and the pedigree of each article. To remedy this want the following table has been drawn out, showing the stems to which belong the various kinds of ammunition we are concerned with here. Many trees of a somewhat similar nature might of course be constructed, fuller and more scientific than Table IV.; but it has the advantage of being very simple and sufficiently comprehensive for the present purpose.

Strictly speaking, the table ought to have included *all* the ammunition in use between the introduction of cannon and the introduction of rifled arms in the middle of the last century; but the principle has not been pushed to its limit, nor was it necessary to do so in order to enable the reader to form a clear notion of the broad divisions

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of ammunition. Machines lingered on for some time after the invention of cannon: in fact they were used at the siege of Constantinople in 1453. Their stone balls and pots of Greek fire are not formally included, because what is said of stone shot for guns in Chap. XIII. applies equally to stone balls for machines, and all that it was considered necessary to say about Greek fire has been said in Chap. III. Electric fuzes, and some few species of ammunition of little interest or value, have been also omitted, because their inclusion would have increased the size and complexity of the table without any counterbalancing advantage.

Ammunition for rifled guns has not been included, because it is for the most part an adaptation and development of smooth-bore ammunition.

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TABLE IV

AMMUNITION

- Hand
  - Fire Arrows, &c.
  - Grenades, Incend. and Explos.
- Automatic
  - Rockets, War
- Cannon
  - Charge
    - Gunpowder
  - Projectiles
    - Shock
      - Darts, &c.
      - Stone
      - Iron
      - Bronze
      - Lead
      - Round Shot
      - Case
      - Shrapnel
    - Incendiary
      - Hot Shot
      - Fireballs
      - Shell
      - Carcasses
    - Explosive
      - Fireballs
      - Shell
- Igniters
  - Hot Wires
  - Priming Powder
  - Matches, Slow and Quick
  - Portfires
  - Tubes
  - Time
  - Percussion
  - Concussion
  - Fuzes
- Signals
  - Rockets
  - Fixed Lights

CHAPTER X

HAND AMMUNITION

Fire-Arrows and Fire-Pikes

THE system of attaching incendiaries to arrows, lances, &c., survived the introduction of gunpowder and died a lingering death. In November 1588 the Government ordered the purchase of "20 Slurr Bows at 25s. each, and 20 doz. of firework arrows for the said slurr bows at 5s. the doz."[1] From a list of naval stores for the year 1599, it would appear that fire-arrows were discharged from long-bows as well as slur-bows :—

> "Slurbowe arrowes with firewoorkes, 184;
> inde 19 without firewoorkes.
> Longbowe arrowes with firewoorkes, 4 shef. 1 arr."[2]

Hansard gives a plate of an English archer, 1250, with *spicula ignita*, or arrow tipped with wildfire.[3] Sir R. W. Payne-Gallwey gives a sketch of a slur-bow. It is a cross-bow, with a barrel and a single string which works in two slits cut in the sides of the barrel.[4]

Fire-lances were used, perhaps for the last time,

[1] "State Papers," Domestic Series, 1581–90.

[2] "Archæologia," xiii. 27, 397–400. The term *slur-bow* is, I presume, akin to the German *schleuderbogen*.

[3] "The Book of Archery," London, 1840, Pl. xvii., No. 5.

[4] "The Cross-bow," 1903, fig. 84, p. 129.

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at the first siege of Bristol, 1643. There, Prince Rupert tells us, "Captain Clerk, Ancient Hodgkinson, and some others running in upon (the Royalists) with fire-pikes, neither men nor horses were able to endure it. The fire-pikes did the feat."[1]

Fire-arrows had a longer spell of existence, and were used by the Chinese against the French in 1860.[2]

Hand Grenades

Incendiary hand grenades are of great antiquity. We have seen that earthenware grenades were used at the siege of Salonika,[3] 904. Towards the end of the thirteenth century Hassan er-Rammah describes grenades made of bark, papyrus, or glass—materials well adapted to break up on impact and scatter about their burning contents.[4] They were used at the passage of the Lys in 1382:—"Adonc vinrent arbalêtriers et gens de pied avant; et si en y avait aucuns qui jetait de bombardes portatives et qui traioient grands quarriaulx empennés de fer," &c.[5] By a common figure of speech Froissart calls the grenade a bombard, just as the author of the "Avowing of Arthur" calls a shot a gun:—

". . . there came fliand a gunne
And lemet as the leuyn . . ."[6]
(A gun came flying by and gleamed like lightning.)

[1] Rupert's Diary, in Warburton, "Prince Rupert," iii. 163.
[2] Napoleon III., iii. 261.
[3] Ὀστράκινα σκεύη—earthenware vessels. J. Cameniata, p. 527.
[4] Reinaud and Favé, in *Jour. Asiatique*, 1849.
[5] Froissart's "Chronicles," ed. Bouchon; ii., ch. 181, p. 235.
[6] St. 65, ed. Robson.

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The plate from the MS. of Kyeser's *Bellifortis*, 1405, given by Herr von Romocki (i. 169), shows three projectiles which were unquestionably hand grenades. Figs. 25 and 30 are provided with spikes, like crow's-feet.[1] Fig. 27 is a flask or bottle of the same family as Hassan's grenades, and was probably made of earthenware. It was by an explosive earthenware grenade that Del Vasto was severely wounded in 1528, during the sea-fight between the French and Spaniards off Cape Campanella.[2] The Comte de Rendan was killed by a grenade of unknown construction at the siege of Rouen, 1562,[3] and grenades were freely used at the siege of Famagusta, 1572. Du Bellay tells us that grenades were made in large quantities at Arles in 1536.[4] As it is improbable that iron grenades could have been turned out in large quantities in the first half of the sixteenth century, we may conclude that they were either earthenware or some form of brittle brass. This is rendered probable by Whitehorne's remarks on the subject. He says that "earthen bottles or pottes," filled with incendiary or explosive matter, had been formerly used; but he recommends

[1] According to Sir Walter Scott, the Scotch in the beginning of the last century still called crow's-feet *calthrops*, a word which goes back to "Piers Plowman," cir. 1393:—"The Rev. Dr. Heavysterne from the Low Countries sustained much injury by sitting down suddenly and incautiously on three ancient calthrops" ("Antiquary," ch. iii.).

[2] "Fictili globo incendiarii pulveris."—P. Jovii, *Hist. sui Temp.*, i., c. 18.

[3] *Mém. de Castelnau*, ed. Bouchon; xiii., p. 154.

[4] *Mém. de Messire du Bellay*, ed. Bouchon, vii., p. 632.

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"hollow balles of metal, as bigge as smal boules and ¼ in. thick, cast in mouldes and made of 3 partes of brasse and 1 of tinne." Their charge consisted of "3 partes serpentine, 3 partes fine corne pouder, and 1 part rosen." A little fine corned powder was used as priming; and he directs the grenades to be "quickly thrown," as they will almost immediately "breake and flye into a thousand pieces." The want of a proper fuze rendered their use so dangerous that he advises trials to be made with them, "to see how long they will tarry before they breake."[1]

Major Ralph Adye mentions that grenades were supposed to be capable of being thrown 13 fathoms, or 26 yards.[2]

Evelyn says in his "Diary" that on 29th June 1678, he saw at the Hounslow Camp certain soldiers "called granadiers, who were dexterous in flinging hand-granades." In the *Archæological Journal*, xxiii., 22, will be found a plate "Blow your Match," after a sketch by Lens, "limner to His Majesty" George II., which represents a grenadier of the 1st Regiment of the Guards in 1735, grenade in hand.

[1] Fol. 41. These brazen grenades of Whitehorne's correspond to the "Kobber-Granater" shown in the books of the Copenhagen Arsenal at the beginning of the seventeenth century. Blom's *Kristian d. IV.'s Artilleri*, pp. 268–69.

[2] "The Bombardier," 1802, p. 147.

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CHAPTER XI

WAR ROCKETS

INCENDIARY rockets were known in the East from an early time, and they are frequently mentioned at later periods; but we are told so little about the loss they inflicted upon an enemy that one is inclined to suspect their effect was confined to wounding a few men and frightening elephants and horses. They are said to have been used by the Chinese against the Tatars in 1232.[1] The *Malzufat-i Timuri* and the *Zafarnama* leave us in doubt whether Timur's rockets were used or not at the great battle of Delhi, 1399.[2] The effect produced by a single rocket led to the fall of the strong fort of Bitar in 1657, but this result was purely accidental. The commander of the fort, foreseeing that an assault would be made upon one of the bastions which had been much damaged by artillery fire, ordered a hole to be dug in it and filled with gunpowder, grenades, &c., intending to blow up the besiegers when they entered. Just before the assault was made, one of the besiegers' rockets fell by accident into this pit and fired its contents, creating thereby so much loss and

[1] *Danduli Chronicon*, Muratori, xii. 448, in Elliot, vi. 469.
[2] In Elliot, vol. iii.

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confusion among the garrison that the place was carried after a short struggle by Aurangzeb's troops.[1]

In the West, rockets were employed as early as 1380,[2] if not earlier; but they were never looked on with favour, and they appear to have been seldom, if ever, used between the earlier part of the fifteenth century and our bombardment of Boulogne with Congreve rockets in 1806. Dunois' capture of Pont Audemer in 1449 was a consequence of a fire that broke out in the town; but the fire appears to have been caused by a hand-grenade or fire-arrow, not by a rocket. However, the exact meaning of the word *fusus* is so doubtful that the matter is not worth pursuing.[3]

Towards the close of the eighteenth century rockets were almost forgotten in the one European city where they were most likely to have been remembered—Constantinople. In 1783–84 Tipu Sultan sent a mission to the Sultan of Turkey, and of the presents which they offered "none were so much admired as the Rockets, of which there were none in that country."[4]

[1] In Elliot, vii. 125.

[2] In the war of Chiozza. During the attack on the Torre della Bebbe, "furono tirate molte rochette."—Muratori, xv. 769.

[3] "Ecce quidam adolescens . . . quid Græcus ignis potest experiri vellet . . . fusum sulphure ignitum . . . ad quamdam domum, stipula et stramine coopertam, maximo impetu traxit. Iterum, alium et alium transjecit. Acriori incendio edes accense concremantur."—*Œuvres de R. Blondel*, pub. by "Soc. de l'Hist. de Normandie," ii. 74. Little is known of Blondel's life, but he was alive in the year 1460. I believe *fusus* to be the *fusée de feu* of the *Livre de Canonerie*, Paris, 1561 (Reinaud and Favé, p. 140), and this incendiary was not a rocket.

[4] "Hist. of Tipu Sultan," by Husain Kirmani, trans. by Col. Miles, p. 145.

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We find traces of the employment of rockets, both incendiary and explosive, in India in this very year, when some "rocketeers . . . threw confusion and dispersion into the masses of the Mahrattas."[1] Nothing can be more probable: the army of the Mahrattas was an army of cavalry, and horses are terrified by fire in any form. The Indian rocket at this time had a tube of 8″ length and 1.5″ diameter,[2] and it does not appear to have been a very effective missile. Speaking of our loss during the attack on Seringapatam, 1792, Colonel Dirom says: "(We had) a good many wounded, though in general but slightly, chiefly by rockets."[3] Within the next few years, however, rockets were much improved, and an eye-witness speaks of the use of "rockets of an uncommon weight" at the siege of Seringapatam, 1799.[4] These were undoubtedly explosive rockets, for Col. Gerrard saw one of them kill three and wound four of our men.[5]

Shortly after the taking of Seringapatam the Ordnance Office applied to the Laboratory, Woolwich Arsenal, for the services of some one who understood the manufacture of war rockets. The Laboratory referred the Ordnance to the East India Company, who replied that they knew of no one who possessed

[1] "Hist. of Tipu Sultan," by Husain Kirmani, p. 109.

[2] "Narrative of the Conquest of Mysore," Hull, 1804, p. 50.

[3] "Narrative of the Campaign with Tippoo Sultan," London, 1793, p. 209.

[4] "Narrative of the Conquest of Mysore," p. 52. Their charge was 1 lb. of powder, and their range about 1000 yards. "Description of Indian and Oriental Armour," by Lord Egerton of Tatton, 1896, p. 32.

[5] "Ammunition," pt. ii. p. 174, by Capt. C. O. Browne, R.A.

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such knowledge.[1] This state of things led Colonel Congreve to turn his attention to the subject. It is not correct to say that he brought rockets from India,[2] for he never was there. He knew of course —the whole world knew—that war rockets were employed there: "I knew that rockets were used for military purposes in India, but that their magnitude was inconsiderable and their range not exceeding 1000 yards."[3] His object was to make large incendiary and explosive rockets with a range of 1000–3500 yards, and he succeeded, perhaps, as well as the materials at his disposal permitted. He never laid claim to the invention of war rockets: "What I have done," he says, "towards the perfection of this weapon is as much my own as if the original invention of rockets in general were mine."[4]

Oberst-Lieutenant Jähns tells us that, from a certain point of view, the Emperor Caligula's rockets were on a level with those of Congreve.[5] It may be doubted, however, whether Caligula's rockets would have produced the same effect as the Congreve rockets at Copenhagen in 1807,[6] or at Walcheren in the same year, when the French Commandant,

[1] Sir W. Congreve's "Concise Account of the Rocket System," London, 1807, p. 42. He held his commission in the Hanoverian army.

[2] Jähns, p. 523; Romocki, i. 69 *n.*

[3] Congreve, as above, p. 1. [4] Ib., p. 42.

[5] "In dieser Hinsicht standen also die Feuerwerker der Zeit des Caligula wol schon auf derselben Höhe wie Congreve, dessen 'Geheimnis' zu Anfang des 19 Jahrhunderts so angestaunt wurde!" (p. 516.)

[6] "Furchtbare Wirkung." Decker's *Gesch. des Geschützwesens*, &c., 1822, p. 79.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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 $\frac{1}{3}$ 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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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 $\frac{1}{7\,3\,0}$ 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.

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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.

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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.

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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.

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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.

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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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was wrapped in a leather covering, so as to fit the bore tightly. Experience quickly proved these darts to be quite unsuited for firearms; yet they dragged on a lingering and precarious existence for quite 250 years. In the anonymous *Livre de Canonnerie et Artifice de feu*, Paris, 1561, the title of the seventy-fourth chapter is: "Pour tirer lances ferrées d'une bombarde, canon ou autre baston à feu de cannonerie."[1] To a return of the powder on board his squadron, dated March 30, 1588, addressed to Government, Sir Francis Drake added a P.S.: "Forgett not the 500 musketts, and at least 1000 arrows";[2] and on the 8th April following the Privy Council ordered him to be supplied with "muskittes, 200; arrowes for the said muskittes with tamkines for eche, 1000."[3]

Round Shot.

On the failure of the darts, informal trials were begun everywhere with balls of stone, iron, bronze, and lead, to discover which material was best suited for ordnance.

Stone shot, which had been used in machines for countless centuries, were on trial for cannon in France in 1346;[4] and, unless a ballad written about this time refers to machines and not to guns, we

[1] Reinaud and Favé, p. 168.
[2] "Calendar, State Papers," Dom. Ser., 1581–90, March 30, 1588.
[3] "Acts of the Privy Council," New Ser., xvi. 25.
[4] Napoleon III., iii. 96.

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employed them at the siege of Calais the same year:—

"Gonners to schew their art
Into the town in many a parte
Schot many a fulle great stone.
Thanked be God and Mary mild,
They hurt neyther man, woman, nor child;
To the houses, though, they did harm."[1]

Stone shot were in use in Italy in 1364,[2] and in 1378 Richard II. ordered 600 stones to be bought for the cannon in the castle of Brest.[3] They were employed more or less in England and elsewhere until the Great Rebellion, and possibly even later.

The earliest mention of iron shot, perhaps, is that in the Arderne MSS., say 1350;[4] although we should not be justified in inferring from it that they were then in actual use. There were 928 iron shot in the arsenal of Bologna in 1381,[5] but iron seems to have been sparingly employed until the time of Charles VIII. of France, 1483–98.[6] The only iron

[1] Wright and Halliwell's *Reliquiæ Antiquæ*, London, 1841.

[2] Muratori, *Rer. Ital. Script.*, xv., col. 182.

[3] Rymer's *Fœdera*, vii. 187.

[4] No reliance can be placed on the document given in Libri's *Hist. des Sciences Mathém. en Italie*, iv. 487, which states that there were cannon and iron shot in Florence on the 11th February 1326. Libri was expelled from the French Academy, and sentenced to ten years' imprisonment in 1850 for falsifying and selling public documents which he had stolen from various institutions.

[5] Napoleon III., i. 358.

[6] Beringuccio calls iron shot "cosa nova all' uso della guerra; perchè non prima (che io sappi) furono vedute palle di ferro in Italia per tirarle con artiglierie, che quelle che ci condusse Carlo Re di Franchia contra Re Ferdinando l'anno 1495."—*Pyrotechnia*, Venice, 1559, p. 247.

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projectiles mentioned by (or, we may infer, known to) the authors of the Berlin Firebook, 1400–50,[1] and of the *Tractatus de Pugnaculis* of the same period preserved in the Hof-Bibliothek at Vienna,[2] are iron bullets for handguns. When used against troops in wooden buildings, &c., they both recommend that the balls should be heated red-hot. Hot (cannon) balls were introduced much later, in 1579, by Stephen Bathory, King of Poland.[3] It was a simple matter to discharge hot projectiles from a machine, but a delicate operation to load a gun with them without exploding the charge. In fact, it was impracticable until the thick wet wad had been devised.

It appears from Petrarch's *De Remediis Utriusque Fortunæ*,[4] which must have been written in or before 1344, that bronze shot—*glandes æneas*—were then in use among the Italians; and Valturio mentions bronze shells—*pilæ æneæ*—in his work, which, although not published until 1472, was already written in 1463.[5]

A document, dated 29th April 1345, proves that the French were employing lead shot at this time;[6] and the accounts of Robert de Mildenhale, Keeper of Edward III.'s Wardrobe, show that we sent to

[1] MSS. germ. qu., 1018.

[2] Meynert's *Gesch. des Kriegswesens*, &c., Vienna, 1868, i. 378.

[3] *A Rege ipso institutum;* Heidenstein, *De Bell. Moscovito*, 1588, p. 40. They were in use in Denmark in 1592. Blom's *Kristian d. IV.'s Artilleri*, p. 266.

[4] Geneva, 1645, p. 303.

[5] *De ReMilitari*, Verona, 1472, lib. 10, c. iv. p. 267.

[6] Napoleon III., iii. 80.

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Calais on the 1st and 2nd September 1346, 73 large leaden shot, 31 small shot, and 6 pieces of lead.[1] Finally, the accounts of John de Sleaford, Clerk of the King's Privy Wardrobe, prove that in 1372–74 workmen were employed in the Tower in making leaden "pelottes" for guns.[2]

In a battle at Taro, 1491, the Venetians are said to have fired upon the French with shot of all three metals—iron, bronze, and lead.[3]

These trials naturally resulted in the general, but by no means exclusive, adoption of stone as the best material for round shot; because it was found that not only the use of metal balls was considerably more costly than that of stone, but that the heavier charges of powder necessitated by metal shot exerted a destructive effect upon the feeble cannon.

The respective prices per lb. of iron,[4] gun-metal,[5] and lead[6] in the second half of the fourteenth

[1] Mr. J. Burtt, in *Archæol. Journal*, xix. 68.

[2] W. L. Clowes, "The Royal Navy," 1897, i. 149.

[3] Benedict. Veron., *De Rebus Carol. VIII.*, in Eccardi, *Script. Rer. Germ.*, ii. (Jähns).

At the siege of Bilqan in Persia by the Moguls under Prince Hulágu in 1256, stones not being procurable for the machines, wooden shell filled with lead were employed with good effect.—*Heft Iqlim*, Persian MS. in Bib. Nat., Paris, No. 356, fol. 500.

[4] Average price, 1371–80. Rogers' "Hist. of Agriculture and Prices," i. 484.

[5] 90.5 per cent. copper and 9.5 per cent. tin; copper at 2s.34d. per lb. (average, 1303–53); tin at 3.41d. per lb. (average, 1371–80). Mr. Rogers notices the rareness of copper, 1350–1400. Ib., i. 484; ii. 531. The bronze of an Egyptian mirror, *cir.* 1750 B.C., was found by M. Berthelot to consist of 91 per cent. copper and 9 per cent. tin.—*Introd. Alchimistes Grecs*, p. 221.

[6] Ib., i. 605 (average, 1371–80). There is some little uncertainty about the exact price of lead owing to the "fother" having three

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century were .856, 2.44, and .627 pennies, fourteenth century money. Multiplying by 10, to get their approximate prices in our money, we obtain:—

TABLE IX.

Comparative Prices of Metals, 1375 and 1865.

Metal.	Price per lb., 1375, multiplied by 10. *d.*	Ratio.	Price per lb., 1865. *d.*	
Iron	8.56	8.5 to 5.7	1 to 1.5	Bar iron of average quality
Gun-metal.	24.4	2.03	12	
Lead	6.27	3.13	2	

It will be noticed that the price of bronze, which had been brought to perfection by the ancients, and whose manufacture was independent of modern appliances, only fell to half its old price in five centuries; that the price of lead, which had some dependence on these appliances, fell to a little over one-third; while the price of iron, whose progress depended essentially upon the use of coal, scientific furnaces, &c., fell to between one-fifth to one-ninth.

The weights of (wrought) iron,[1] bronze,[2] and lead

meanings. "In the Book of Rates it is said to be two thousand pound-weight; at the mines it is twenty-two hundred and a half; and among the Plummers at London, nineteen hundred and a half." "The New World of Words," 6th ed., by E. Phillips, London, 1706. I have taken the 2000 lbs. of the Book of Rates.

[1] There was no cast-iron in the fourteenth century.

[2] I have taken the proportions for bronze as given for shell by G. della Valle in his *Vallo*, Venice, 1521: 75 per cent. copper and 25 per cent. tin, which had a sp. gr. of 8.4 and cost 2.6d. per lb.

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balls of 4″ diameter are respectively 9.3, 10.18, and 13.8 lbs., and Master Gunner Nye informs us that the weight of a stone ball of this diameter was 3.375 lbs.[1] Therefore the respective prices of the iron, bronze, and lead balls were 7.96, 26.468, and 8.65 pence, exclusive of the cost of manufacture; while the price of the material of the stone ball was much less than a farthing.[2] Again, for powder at 13.664d. per lb.,[3] and charges one-ninth the weight of the shot, the prices of the charges for the stone, iron, bronze, and lead balls are respectively 5.12, 14.07, 15.44, and 20.496 pence. We can therefore form an estimate of the relative cost of one round with balls of the four materials.

TABLE X.

Comparative Cost of One Round, 4.25″ gun; stone, iron, bronze, and lead balls.

	Stone. *d.*	Iron. *d.*	Bronze. *d.*	Lead. *d.*
Price of 4″ ball . . .	.25	7.96	26.468	8.652
Price of powder . . .	5.12	14.07	15.44	20.496
Cost of one Round .	5.37	22.03	41.908	29.148
or in our money .	4s. 5¾d.	18s. 4½d.	34s. 11d.	24s. 3½d.

[1] This gives a sp. gr. of 3.1, and shows that the stone was probably limestone, although Nye objects to "freestone" for shot and recommends "marble, pibble stones, and hard blew stones," p. 58. "Pibbilston" is found in Wiclif's Bible, Prov. xx. 17, *cir.* 1383.

[2] Limestone sold in 1664 at 3s. 6d. a ton; Rogers, v. 508. But the wages of a gunstone-maker in Queen Elizabeth's reign were 6d. a day, or about 3s. 6d. of our money. Brackenbury, v. 2 *n.*

[3] See p. 185.

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These figures do not profess to give the absolute price of one round, but they represent pretty accurately the relative cost of a round with the different projectiles.

The pressures per square inch exerted upon the bore of a gun are directly proportional to the weight of the charges used, and these charges were directly proportional to the weights of the projectiles used. We have therefore the following comparative pressures:—

TABLE XI.

Numbers proportional to the pressures per square inch on the bore of a 4.25" gun when fired with shot of different materials.

Stone.	Iron.	Bronze.	Lead.
3.6	10	10.9	14.5

Table X. shows that the cost per round with stone was much less than with metal shot, while Table XI. shows how great was the disparity between the pressures on the bore in the two cases, which, as the calibre (and therefore the absolute pressure) increased, became a serious matter. With the very small, early guns, the greater cost and heavier strain may not have been sensibly felt. The extra cost in their case was not very considerable, and the increased pressure may not have been even suspected until guns began to burst.[1] But that

[1] The early gunners suffered terribly from the bursting of their guns. James II. of Scotland was killed in 1460 by the bursting of a

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these disadvantages made themselves unmistakably felt when the guns grew larger is proved beyond a doubt by the fact that "great stone shot and great cannon were introduced together."[1] Leaden bullets were retained for hand-guns, because it was comparatively easy to strengthen them, and the metal, although dearer per bullet than iron, was much easier to manipulate. Iron shot were doubtless used as a general rule for breaching purposes, for which stone shot were ill adapted, owing to their lightness and liability to break up. We even hear from time to time of the use of bronze and lead cannon balls.

Case.

There were two ways, in early times, of firing a volley of small shot at troops. The first consisted in mounting a number of small bombards on one carriage and firing them all, or a certain number of them, together. Gattaro speaks of 144 bombards mounted on the same bed, and so arranged as to fire thirty-six at a time.[2] The whole apparatus was called a *ribaudequin*, *barricade*, *orgue*, *orgelgeschütz*, &c.; the two latter names being given to it because it resembled "organ-pipes placed upon a broad carriage."[3] By the second method the bullets required

gun, and a bombard burst near Paris in 1479, killing fourteen men, and wounding fifteen or sixteen. *Libre de Faits*, Jean de Troyes, ed. Bouchon, p. 340. The Emperor Babar tells us of a gun that burst in India in 1527–8, killing eight men. Elliott's "Hist. of India," iv. 272. And so on.

[1] Brackenbury, v. 30.

[2] Muratori, *Rer. Ital. Script.*, xvii., col. 558.

[3] R. Norton, "The Gunner," &c., London, 1628, p. 158.

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for the volley were put for convenience in a cartridge case or canister, and fired from a large bombard. The bullets, according to General Köhler, were simply pebbles of flint.[1] During the Indian Mutiny, I forget where, a volley of "Pyramid" or "Pool" balls was fired by the mutineers from a clubhouse upon our storming party with deadly effect.

Essenwein gives plates of an orgue, dated 1390–1400, and of a gun firing case dated 1410.[2] Case was used at the siege of Belgrade, 1439,[3] and at the siege of Scutari, 1478.[4] Orgues were used as late as the Great Rebellion. At the battle of Copredy Bridge, 1644, the Cavaliers took "two baricadoes of wood, which were drawn upon wheels, and in each seven small brass and leather cannon, charged with case."[5]

Shrapnel.

Isolated attempts to fire shell from guns (as distinguished from howitzers and mortars) had been made from time to time in the course of the seventeenth and eighteenth centuries, but they proved, one and all of them, abortive. The first methodical and successful shell-fire from guns was carried on during the siege of Gibraltar, 1779–83, at the suggestion of an English Infantry officer.

[1] *Entwickelung des Kriegswesens*, Breslau, 1886, iii. 266.

[2] *Quellen zur Geschichte des Feuerwaffen*, 1872, A, viii., xix.

[3] Ducas, *Hist. Byzant.*, Bonn, 1831, p. 211.

[4] Sabellicus, *Hist. Venet.*, Dec. iii., lib. 10 (Jähns).

[5] Clarendon's "Hist. of the Great Rebellion," p. 522. Boillot calls orgues "barriquades," *Modelles Artifices de feu*, &c., Chaumont, 1598, p. 189.

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The distance from our nearest batteries to the Spanish lines when the siege began was 1700 to 2000 yards,[1] and at this range our fire was ineffective. Many of the mortar shell burst at the muzzle from the heavy charges required for these long ranges, a gunner losing his life on one occasion from this cause.[2] The shell that withstood the shock flew wildly; the fuzes were "in general faulty";[3] many good shell were smothered in the sand of which the Spanish works were constructed; those that burst produced but little effect;[4] and round shot were of no avail against sandbanks twenty-two feet high. As fire against the Spanish works was useless, it only remained to direct it on the working parties. Against them our mortar fire was as ineffective as against the works, and what was to be looked for from guns provided only with round shot and case? Case would not carry one-sixth of the range, and round shot against handfuls of men, scattered here and there, were as worthless as shell. The difficulty was still unsolved when Captain Mercier, 39th Regiment, suggested firing the 5.5-inch shell of the royal mortars, with *short* fuzes, from the 24-pounder guns which had the same calibre as the mortars, 5.8-inch. A trial was made on the 25th September

[1] See Admiralty survey of Gibraltar, by Capt. Aldrich, R.N.

[2] "Die Granate vor dem Stück crepirt . . . wodurch ein Artillerist das Leben verloren habe." *Neues militärisches Hannovranisches Journal*, Stück iv., p. 225, kindly communicated to me by Major W. Balck, German General Staff. Apparently by an eye-witness.

[3] Drinkwater's "Siege of Gibraltar," 1786, p. 87.

[4] "Die Bomben fielen so tief in den Sand, dass die Stücke niemand schaden konnten." *Hannovranisches Journal*, as above.

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1779, with (I believe) the "Rock gun," which was a 24-pounder; the "calculated fuzes,"[1] it was found, "often burst (the shell) over the heads of the working parties,"[2] and Mercier's brilliant proposal was officially adopted.

When the siege was over, and men had time to think, it became clear enough that excellent as was Captain Mercier's plan as a makeshift during the stress and strain of a siege, it had its weak points. The strong charge necessary to burst the common shell tended to scatter the fragments here and there in all directions, and the fragments were few in number. Experiments were carried on in Prussia in 1761 to determine the bursting charges which broke (mortar and howitzer) shell into the greatest number of pieces. It was found that royal mortar shell (*maximum* bursting charge, 1 lb. 2 oz.) broke into eight pieces, with a bursting charge of 1 lb., and into nineteen pieces with a bursting charge of 14 oz., these figures being the means of six trials.[3]

In any case, the siege of Gibraltar proved beyond denial that we possessed no recognised and effective projectile against troops in open order beyond the range of case. To fill the void thus disclosed in our

[1] Capt. Sayer's "Hist. of Gibraltar," 1862, p. 291.

[2] Drinkwater, p. 89. The Hanoverian officer, speaking of the trial, says: "Versuch, welcher der Erwartung vollkommen entsprach." Of the effect of the fire on the enemy he says: "Die Brandröhren (waren) so genau bestimmt, dass die Bombe oft den Feind über den Köpfen crepirte . . . und incommodirte den Feind unaufhörlich." *Journal*, as before.

[3] "Universal Military Dictionary," by Capt. G. Smith, R.A., 1779, art. "Shell."

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ammunition, Lieutenant Henry Shrapnel, R.A., conceived the idea in 1784[1] of a gun-projectile, which he called "spherical case." As he was quartered in Newfoundland during the siege, it is improbable that he was aware at this time of Capt. Mercier's plan. At all events he did not follow it, the principle of his invention being radically different from that of common shell. The bursting charge of the latter was a *maximum*, the bursting charge of the former was a *minimum;* the fuze of the latter was bored long, the fuze of the former was bored short; the fragments of common shell were projected by the bursting charge of the shell, the fragments of the shrapnel by the charge of the gun from which it was fired.

This absolutely new and original invention at first met the fate of many other new inventions—it was long disregarded.[2] Not until 1803, when England was in grave danger, did the authorities bestir themselves about it: a trial of Shrapnel's shell was then ordered, and the Ordnance Committee reported in their favour.[3] How great an invention these shell were may be measured by their inextinguishable

[1] Writing on 5th April 1813, Shrapnel said it was "nearly thirty years" since he began his experiments. "Synopsis of Reports and Experiments by the Ordnance Select Committee: Shrapnel Shell," 1858.

[2] "Ammunition," by Capt. (afterwards Col. Sir V. D.) Majendie, R.A., 1867, i. 350 *ff.*; "Memoirs of Sir J. Sinclair," ii. 244.

[3] Shrapnel's shell failed at the first trial, 3rd June 1803—they were too thin. After the second trial, 29th June 1803, "about a dozen" were recommended to be supplied to ships for each carronade. —Ord. Sel. Committee, "Shrapnel Shell," p. 2.

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vitality: they outlived official apathy; they overcame endless objections; they survived countless modifications; they adapted themselves to rifled guns; and at the present moment they are the best projectiles available against troops in open order beyond the range of case.

The originality of the Shrapnel shell did not, of course, remain unchallenged. Certain officers in France, Germany, and Belgium discovered that the invention was an old one, and that Master Gunner Samuel Zimmermann had employed Shrapnel no later than 1573. His MS., it may be observed, had been removed from Heidelberg to Rome during the Thirty Years' War; was sent back to Heidelberg in 1816; and was not discovered by Hauptmann Toll until 1852, just ten years after Shrapnel's death.[1]

Zimmermann's projectile was not constructed on Shrapnel's principles.

It consisted of a leaden cylinder, with a time fuze fixed in the end placed next to the charge of the gun. The back half of the cylinder was filled with strong (*röschem*) powder; the front half with bullets; and the missile was intended to act a few hundred paces (*etlich hundert schrytt*) beyond the ordinary range of case, say, at 500–600 yards. A very small bursting charge would have sufficed

[1] *Die Shrapnels: eine Erfindung des 16-ten Jahrhunderts*, in "*Archiv für die Officiere der K. Preuss. Artillerie, &c.*," Berlin, 1852, Band 32, p. 160. Toll does not allude to Shrapnel personally. He gives the text of Zimmerman's MS., which I quote above.

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to burst open a leaden case: why, then, did the Master Gunner use the *maximum* charge which was possible without unduly diminishing the number of bullets—a charge, too, of specially strong powder? Because he intended the bursting charge not only to open the case, but to accelerate the velocity of the bullets—he could have had no other conceivable reason.

Whatever may have been the merits of this missile, it was certainly not a Shrapnel, as will be seen clearly by placing the details of construction of the two projectiles side by side.

Zimmermann's Case, 1573.	*Shrapnel's Spherical Case*, 1805.
(*a*) A hollow leaden cylinder.	(*a'*) A hollow iron sphere.
(*b*) Thickness of cylinder unknown.	(*b'*) Thickness of sphere a *minimum*.[1]
(*c*) Contained a number of bullets.[2]	(*c'*) Contained a number of bullets.
(*d*) Bursting charge a *maximum*.	(*d'*) Bursting charge a *minimum*.
(*e*) Bullets accelerated by explosion of bursting charge.	(*e'*) Bullets (as far as practicable) unaffected by explosion of bursting charge.
(*f*) A very bad fuze.	(*f'*) A tolerably fair fuze.[3]
(*g*) Range up to 500–600 yds.	(*g'*) Range up to 3000 yds.

[1] One of Boillot's mortar shell, which nobody has yet claimed to have been a Shrapnel, was of *minimum* thickness, "afin qu'elle rompe plus facilement."—*Modelles, Artifices de feu, &c.*, Chaumont, 1598, p. 163.

[2] Some of Boillot's mortar shell contained bullets, not only inside but outside, where they were stuck into some glutinous substance with which the shell was covered. Ib., p. 167.

[3] Capt. May, R.A., reported that before reaching the Great Belt, 1807 (on the voyage to the siege of Copenhagen), Shrapnel's own fuzes were found to be so affected by the damp as to be unserviceable, and that others had to be improvised.—Ord. Sel. Com., "Shrapnel Shell," for 19th June 1809.

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The annals of Artillery will be ransacked in vain for Shrapnel shell before the nineteenth century, because the successful application of Shrapnel's principle was impossible until an extremely accurate time fuze had been constructed, and no nation possessed a really good fuze before that epoch[1]—nor in truth until long afterwards. The results of the Shrapnel practice in 1819,[2] after Shrapnel and many others had devoted their best energies to the improvement of time fuzes for sixteen years, show how defective they still were. But although the want of a sufficiently accurate fuze made the Shrapnel system a practical impossibility before the nineteenth century, a man above his fellows might have dreamt dreams of distant case fire ages before.

That Zimmermann was groping about blindly in search of the projectile Shrapnel found in 1784, is proved beyond a doubt by the question which the Feuerwerker puts to the Büchsenmeister: "Cannot a case shot be made which will leave the bore whole and burst at a few hundred paces' distance?"[3] But

[1] "Ehe die Zünder nicht zu der Vollkommenheit gekommen waren, genau tempirt werden zu konnen, was erst gegen das Ende des vorigen (18-ten) Jahrhunderts eintrat, konnte uberhaupt von der Erreichung einer Wirkung, wie sie Shrapnel vor Augen hatte, gar nicht die Rede sein; und es ist das unstreitbare Verdienst Shrapnels, dass er die Vervollkommung der Zünder zur Erreichung bis dahin nicht gekannter Kartätschwirkung benuzte."—"Notiz über die Geschichte der Shrapnells," by Hauptmann Meyer, in *Archiv für d. Offic. d. K. Preuss. Art., &c.*, 5 Band, zwieter Heft, p. 157.

[2] Given further on.

[3] "Mag auch nicht ain Hagel gemacht werden der ganntz vom Rohr fert und sich erst uber etlich hundert Schrytt nachet oder feer wie man will von einander thut und sich austhaylet?"

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Zimmermann failed in his search: what he sought did not lie on the road that he took. Like Fronsperger,[1] he placed his fuze next the charge, in consequence of which (as the old man frankly confesses) most of his cylinders burst in the bore: "Gemainlich im Stückh angegangen und zersprungen." Boillot, a quarter of a century later, had a better knowledge of gunnery: "adviserez que le trou d'icelle (the fuze-hole) soit du costé de la bouche dudit mortier."[2] Zimmermann filled the front half of his cylinder with bullets and the rear half with strong powder, obviously assuming the stability of the missile in its flight. Now Prof. Greenhill has given us a table showing the *minimum* twist at the muzzle requisite to give stability of rotation to elongated projectiles. If a common shell's length be 3 calibres, it requires a twist of 1 turn in 38.45 calibres; if its length be 4 calibres it requires a twist of 1 turn in 27.6 calibres; and so on.[3] How far, then, would Zimmermann's ill-balanced, smooth-bore cylinder have travelled before it toppled over, with the certain result that, when it did, the large bursting charge would blow the bullets any way but the right way?

Zimmermann's projectile failed, and his sole merit consists in vaguely foreshadowing the Shrapnel, just as Roger Bacon dimly foresaw balloons and ships driven by machinery—"Marine engines can be constructed and worked by one man which will

[1] Napoleon III., iii. 264. [2] *Modelles, &c.*, p. 163.
[3] "Hydrodynamics," in *Ency. Brit.*, p. 457.

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propel the largest vessels quicker than a ship's crew of oarsmen. . . . Flying machines can also be made."[1] His cylinder no more establishes Zimmermann's claim to be the inventor, or even the suggester, of Shrapnel shell, than Bourne's method of shooting "three times in a peece at one lading of her"[2] entitles him to be regarded as the inventor of quick-firing guns.

We should have been spared much unprofitable controversy had foreign critics thought fit to make themselves acquainted with the nature and properties of Shrapnel's Spherical Case before discussing its history. Its history is simple. It was made in England, the invention of an English Artillery officer who owed nothing to earlier gunners in Germany or anywhere else.

[1] "Instrumenta naviganda possunt fieri sine hominibus remigantibus, ut naves maximæ, fluviales et marinæ, ferantur unico homine regente, majori velocitate quam si plenæ essent hominibus. . . . Item possunt fieri instrumenta volandi."—*De Secretis, c.* iv.

[2] "Inventions and Devices," No. 42, fol. 31–2.

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CHAPTER XIV

IGNEOUS PROJECTILES

Hot Shot.

THE Britons set fire to the Roman Camp during Cæsar's second invasion, 54 B.C., by discharging hot balls of clay among the tents.[1] At the attack on Placentia, A.D. 69, igneous missiles were employed (*glandes et missilem ignem*), and probably destroyed the amphitheatre.[2] As before mentioned, hot shot (for cannon) were invented by the Polish king, Stephen Bathory, in 1579.[3] Their greatest triumph was the destruction of d'Arçon's floating batteries and a great part of the Spanish fleet at Gibraltar, 13th September 1782.

Incendiary Fireballs.

The gunners of old encountered great difficulties in their endeavours to introduce igneous projectiles. Their use in the early guns was not absolutely impossible, but it would have been fruitless; for to prove effective an igneous projectile, whether incendiary or explosive, must contain a considerable mass of combustible matter, and this condition could not

[1] Cæsar, *De Bell. Gall.*, v. 43. See also p. 90 here.
[2] Tacitus, "Hist.," ii. 21.
[3] See p. 202.

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be fulfilled with guns of very small calibre. When the calibre had greatly increased, during the last quarter of the fourteenth century, any attempt to employ such igneous projectiles as were in use with the machines must have ended in failure. The action of the machines was similar to that of a sling, and the shells (or envelopes) of their incendiary missiles were made just strong enough to resist the pressure to which they were subjected on discharge, although not strong enough to bear the shock of impact with the object they struck. This broke them up and scattered their blazing contents about. Such projectiles were evidently unfit for use in cannon; for the explosion of the charge would inevitably break them up in the bore, and their viscous contents would travel but a very short way. Owing to these difficulties the machines held their ground to the middle of the fifteenth century, if not longer, and the igneous projectiles ultimately constructed for cannon were developments of the hand-grenade.

In Fig. 31 of the plate from the MS. of Kyeser's "Bellifortis," 1405, given by Herr von Romocki (i. 169), we are shown a projectile which unquestionably belongs to the same family as the *tonneau* which terrified Joinville and his companions;[1] but this barrel could have only been discharged from a machine. Whether Figs. 26 and 28 of the same plate were thrown by hand or machine depended on their size, which we do not know. From their con-

[1] See p. 4.

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struction, with a mere covering of cloth or cordage, we may safely conclude that they were not gun-projectiles.

We are given a detailed account of fireballs in the German Firebook, 1400–50, belonging to the Royal Library, Berlin, MS. Germ. qu. 1018. Missiles are there described which consisted of an interior ball of gunpowder kneaded with spirits of wine, smeared over with thick incendiary matter, rolled tightly in a cover of cotton steeped in the same mixture, and secured by two metal bands at right angles to each other. They could be either thrown by hand or fired from a bombard. In the latter case a hole was bored through the ball and the plug which was used in bombards to close the end of the powder-chamber next the projectile, in order to admit the flame into the interior of the ball. The success of the missile, it was thought, depended on the hole through the ball being exactly opposite the hole through the plug, a condition which could be only fulfilled in a breechloading bombard. The inventor believed that the ball would explode, for he warns the gunner to throw it before the flame reaches the composition, lest it "blow his head off."[1] It is obvious, however, that the gunner's head was quite safe, although he might burn his fingers, when using these incendiary toys which are unknown to military history. The incendiary projectiles actually used in the fifteenth century were comparatively simple and of a different nature. Take, for instance,

[1] "Das es dir den hals nit abstoss." Romocki, i. 189.

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the incendiary cannon-projectile used at the siege of Weissenburg in 1469, just six years after Valturio had presented his book to the Sultan Mahomed II.[1] It consisted of a stone ball, considerably smaller than the bore of the gun, which was smeared over with thick incendiary matter and wrapped in a cloth soaked in the same mixture. This process was continued until the ball was the proper size for the bore.[2] Other incendiary missiles were tried,[3] but none of them, so far as I am aware, had anything in common with the unpractical projectile proposed in the Berlin Firebook.

Incendiary Shell.

A further step is taken in a later edition of the Firebook just quoted, but of the same period,[4] 1400–50. A quill full of incendiary matter is directed to be inserted in the hole through the ball above described, and the whole was enclosed in an envelope or shell of earthenware or iron. An earthenware ball could of course only be thrown by hand: an iron ball would be fired in general from a bombard. The metal shell was formed of two hemispheres of iron fastened together by bands, with a small hole to admit the flame to the quill. A similar envelope, of bronze, is suggested by

[1] Romocki, i. 192 *n.*

[2] Napoleon III., iii. 156. Whitehorne describes a similar fireball, in which tow is used instead of cloth.

[3] Jähns, 810.

[4] "Ungefähr aus derselben Zeit." Romocki, i. 189.

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Valturio in his *De Re Militari*, 1463, p. 267;[1] but in this case the shell is filled with powder, which in all probability was driven in and compressed as tightly as possible with a mallet and drift.[2] The German writer undoubtedly believed that his shell would burst, for he uses such phrases as "chugel dye da springt" and "zerspringt und zerslecht alls umb." Neither his shell or Valturio's would have exploded except under the most exceptional circumstances.

The weakness of the shell leads Herr von Romocki to suppose that Valturio's plate is wrong or grievously exaggerated. I see no grounds for this suspicion: the shell was purposely made weak, so that it might break into two pieces on impact and leave the incendiary charge free to do its work. The missile belonged to the same family as the incendiary projectiles thrown into Roveredo by the Swiss in 1487.[3] There the shell was filled with pitch and rosin: Valturio's shell was charged with powder, but it was probably compressed tightly into the interior of the shell, and powder, especially serpentine

[1] Valturio's plate is reproduced, ib., p. 193.

[2] "Ye vester darynn gestozzen, ye pesser." Berlin Firebook, in ib., p. 192.

[3] "Es waren eiserne Kugeln von geringer Cohärenz, die, mit, Pech und Harz gefüllt, angezündet, aus den Mauerbrechern geschossen wurden. Beim Auschlagen zerschellten diese Kugeln und die Stücke, von deren jedem eine heftige Flamme emporloderte, wurden umhergeschleudert. Das kleineste von ihnen konnte schwer verletzen, weil das Pech hinderte, es abzuschütteln. Niemand vermochte vor diesem Feuer auf den Mauern zu bleiben." Bembo, *Opera*, 1556, i. 15, in Jähns, 810.

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powder, will not explode under such circumstances. When experimenting with gunpowder at New York, Doremus and Budd subjected good modern powder to such hydraulic pressure as to compress it into a solid block without interstices, and on ignition the mass burned quietly away.[1] Valturio's charge was probably reduced to a state approximating more or less closely to that of the New York powder, and it would have exploded but rarely and occasionally. But the mere fact that the shell was made of bronze is a sufficient proof that it was an incendiary missile. Even had the charge been explosive, a bronze envelope would have been only ripped open by it, not broken into many pieces as iron would have been; a fact which Valturio must have known. Finally, the gunners of the fifteenth century were not in possession of a fuze that would have enabled them to carry on fire with explosive shell. The construction of such a fuze (as will be seen in the section on "Time Fuzes") was the work of the following century.

The Berlin Firebook does not profess to give us an account of ammunition actually used in the field; it merely describes certain ammunition proposed for use by a fireworker, or inventor, and it adds his honest convictions of the way in which it would act if manufactured. The excerpts given by Herr von Romocki from the Firebook, in so far as they concern the projectile in question, are simply the specification and opinions of an inventor, and there

[1] Romocki, ii. 21.

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are no grounds for supposing that his missile was ever made or ever tried. If these projectiles had been used with effect in the field, their inventor would surely have been the first to tell us of their success. There is nothing remarkable in the above conclusion: the inventor followed the custom of his age. The value of experiment generally, the absolute necessity for experiment in gunnery, was unknown or altogether underrated in the Middle Ages, and those fireworkers who may have suspected its importance had neither the money nor the opportunity to put their theory into practice. Would Sextus Julius Africanus and Marcus Græcus have bequeathed to us certain preposterous recipes, had they been at the pains and expense of making them and trying them? It was Roger Bacon who wrote: "Experimental science ignores abstract arguments; because, strong though they may be, their conclusions are not perfectly certain until verified by experiment. . . . In these studies experiment alone, not abstract reasoning, leads to certain conclusions."[1] Yet even he, with his "everlasting lamps," has not quite escaped the infection of the prevailing fashion: he never tried these lamps. Bourne has left us a whole book of "Inventions and Devices," and at least one half of Boillot's book is occupied by similar inventions;

[1] "Haec vocatur scientia experimentalis quæ negligit argumenta, quoniam non certificant, quantumcunque sint fortia, nisi simul adsit experientia conclusionis. . . . Sola experientia certificat hic, et non argumentum." *Opus Tertium*, c. 13.

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but neither of them makes the slightest suggestion that any one of his contrivances was ever made or ever tried. We may, then, discard the wholly unpractical proposal of the Berlin Firebook, and accept Valturio's as the earliest incendiary cannon-shell of which we have any detailed account.

Carcasses.

Carcasses were invented in 1672 by a gunner in the service of Christopher van Galen, the fighting Prince Bishop of Munster.[1] They are mentioned in the *London Gazette*, $\frac{1980}{1}$, 1684. They were originally oblong, in order to contain a large quantity of incendiary matter; but their flight was so erratic that it became necessary to make them spherical. Their thickness was at the same time so much reduced, in order to increase their internal capacity, that a large proportion broke up in the bore. To remedy this defect during the siege of Quebec, 1759, "the interval between the powder and the carcass was filled with turf," an arrangement which "produced every desired effect."[2]

Explosive Fireballs.

Explosive fireballs were simply hand-grenades, which, according to the classification of ammunition adopted here, have been already noticed, p. 169.

[1] Daniel's *Hist. de la Milice Française*, 1724, i. 240.
[2] Major Ralph Adye, R.A., "The Bombardier," &c., 1802.

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Explosive Shell.

The step from Valturio's shell to common shell may seem to us now to have been a short and an easy one, yet it took nearly a century to make it; the obstacle that barred the way being neither the envelope nor the bursting charge, but the fuze.

It is impossible to say exactly when, where, or by whom explosive shell were first employed. The want of them had been long felt everywhere, and numberless attempts to manufacture them were made. They may, therefore, have come into being independently in several countries about the same period; a supposition which receives considerable support from the conflicting claims which have been set up, quite honestly no doubt, to their first employment.

We have sound evidence of the manufacture of large mortars and shell in England as early as 1543. In this year Bawd and Collet constructed mortars of 11″ to 19″ in calibre, with cast-iron shell "to be stuffed with fireworks or wildfire," and a match (*i.e.* fuze) "that the firework might be set on fire for to breake in smal pieces, whereof the smallest piece hitting any man would kill or spoile him."[1]

[1] "Annals," &c., p. 584, for the year 1543. Stow died in 1605. The 15½″ mortar, under Firemaster Thomas Wright, which accompanied a small force sent by Cromwell in 1651 to reduce the Royalist castle of Elizabeth in Jersey, may have been one of Bawd and Collet's. Between five and ten rounds were fired daily for several days without any damage to the piece, although the carriage broke down completely on two occasions. The range was 1540 yards, and the shooting accurate. The first round, we may feel certain, was laid with extreme care.

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Stow, to whom we owe these facts, began life as a tailor, and was not familiar with the intricacies of Artillery *matériel;* but it is sufficiently clear that he speaks here of two kinds of projectiles—incendiary shell filled with wildfire, and explosive shell filled with firework. Whether these shell were ever used and, if so, whether their action was successful, there is no evidence to show; but in 1588 took place the sieges of Bergen-op-Zoom and Wachtendonck at which explosive shell were used with much effect, for the first time according to the evidence we at present possess. Reyd, whose *Belgarum aliarumque Gentium Annales* was published in 1600, tells us (lib. viii., p. 182) that during the siege of Bergen-op-Zoom "an Italian deserter to the Dutch devoted himself to the art, hitherto unknown, of making hollow balls of iron or stone, which, when filled with a certain composition and ignited, burst into innumerable fragments like grape stones."[1] Father Strada, S.J., in his *Hist. de la*

"I proffered to lay a wager of ten pounds with Captain Dover," says the Firemaster, "that my first shot should strike the Castle, . . . and by God's providence it did strike one side of the great Tower, where the Granado brake" (*i.e.* exploded). The second shell "brake verie kindly," and for the third he "altered (the) degrees of elevation." Captain Dover may have paid his bet, but the Ordnance Office forgot to remit Wright's pay; hence the "Perfect Narrative of the Particular Service performed by Firemaster Thomas Wright," &c. &c., 1651. The word *explode* is not found before the seventeenth century—see Dr. Murray's "New English Dictionary"—and was sparingly used in Wright's time.

[1] "Italus a Parmensi ad Foederatos perfugiens, inauditam artem jactabat parandi vasa, cavatosque e ferro aut lapide globos, qui in obsessas urbes adigerentur, impleti ejus naturæ materiâ, ut simul ignem concepissent, in innumeros quasi acinos dissilirent."

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Guerre des Pays Bas, Brussels, 1739, speaks as follows (iv. 415):—

"Il n'y avoit rien qui épouvantait davantage les assiégés (in Wachtendonck) que de certaines grosses boules de fonte creuses, et remplies de poudre et d'autres matiéres inextinguibles, qui étant poussées en l'air avec de gros mortiers, accabloient par leur pésanteur tous les lieux sur qui ils tombaient, et en même tems, comme le feu s'y prenoit par des buses qui y étoient attachées, ils rompoient en se crévant et embrasoient tout ce qui étoit à l'entour, sans que l'eau le put éteindre.

On bat la Ville avec une nouvelle espèce de balles qu'on nomme Bombes.

"Cette sorte de boulet, que nous avons vû ajoûter aux grenades, aux pots à feu, &c. . . . fut, dit on, inventée un peu devant le siége de Wachtendonck par un artisan de Venloo. . . . Je sais que quelqu'un (*i.e.* Reyd) a ecrit qu'une pareille expérience avait été faite a Berg-op-Zoom . . . avec un pareil succès par un Italien deserteur des troupes d'Espagne. Au reste, le Comte Mansfeld se servit de cette machine qui fut inventée à Venloo et faisoit dans Wachtendonck une déstruction des maisons et des hommes aussi inévitable qu'elle étoit inopinée."

L'inventeur de ces sortes de boulets.

These passages possess at least one quality of good evidence—they differ about details and agree on the main points; and it is difficult to see how they can be gainsaid or overlooked. We may take it, then, until further evidence (which may possibly exist) is produced, that explosive shell were first used in large numbers and with good effect in 1588.

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CHAPTER XV

IGNITERS

CHARGES of incendiaries and explosives confined in guns, shells, mines, &c., are not fired directly: for convenience and safety they are ignited by means of some intermediate agent, or agents, such as priming powder, fuzes, &c., which are themselves in turn ignited by some other agents. These collective agents are here called Igniters.

Hot Wires, Priming Powder, Matches, and Portfires.

The small early guns, whose recoil was insignificant, seem to have been fired directly by thrusting a hot wire into the powder through the vent.[1] When guns grew bigger, this method had to be abandoned and priming powder came into use.[2] For centuries priming powder consisted of serpentine, or some slow-burning mixture, which was at first laid in a train from some convenient spot to the vent, and was afterwards simply poured on the vent. The advantage of the former proceeding, in securing the safety of the gunners, is pointed out in a very

[1] See the accounts of the bailiffs of St. Omer in 1342, in Napoleon III., iii. 77.

[2] Ib., p. 149.

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old French book :—"vous pourrez retirer affin que vostre baston (*gun*) ne vous face dommage."[1] In the latter case, the priming was ignited in various ways:—by a hot wire; by a match fixed in a lint-stock, which was "a staffe of a yard or two yards long;"[2] and later by a portfire attached to a port-fire-stick.[3]

The objection to priming powder was its liability to be wetted by rain, or blown away by wind.[4]

TABLE XII.

Matches.

Chinese. 13th Century.	Arab. 13th Century.	English. 17th Century.	English. 20th Century.
Cord soaked in a mixture of sulphur and water (and well dried).[5]	Cord of cotton and palm leaves soaked in naphtha and dried.[6]	"Cotton-weeke dipped in gunpowder wet with water" and dried.[7]	"Cotton-wick boiled in a solution of mealed powder and gum, and afterwards dusted over with mealed powder before it is dry.[8]

[1] Reinaud and Favé, p. 158.

[2] Whitehorne, *c.* 25.

[3] Portfires go back to about 1700. Muller's "Treatise on Artillery," p. 202.

[4] The battle of Uddevalla in Sweden, 1677, was decided by *armes blanches*, a prolonged storm of rain having put a stop to all firing. Crichton and Wheaton's "Scandinavia," p. 109.

[5] Père Amiot, in Reinaud and Favé, p. 183.

[6] Hassan, ib., 37.

[7] Nye, p. 68 *bis*, where it is called "priming."

[8] "Quickmatch," in official "Treat. on Ammunition," p. 430.

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Tubes.

Priming powder was ultimately replaced by small tubes, full of combustible matter, which fitted into the vents of guns. Of the multitude of these tubes only a few can be mentioned here. Tubes filled with quickmatch, and primed with mealed powder and spirits of wine, are said to have been in use in the first half of the eighteenth century.[1] In 1778 Captain Sir Charles Douglas, R.N., invented the gun-flint-lock. It was simply a flint-and-steel apparatus, fastened to the ventplate of the gun and worked by a lanyard, which ignited a tube placed in the vent. Captain Douglas introduced this lock into his ship, the *Duke*, at his own expense, and it worked so well that it was officially adopted for the Navy in 1790.[2] It was owing, apparently, to the personal intervention of General Sir Alexander Dickson that this lock was at length adopted for the Artillery in 1820.[3] In a letter to Sir Howard Douglas (son of Sir Charles), 18th April 1818, Sir Alexander gives his reasons for advocating the change:—"By the employment of slow match only, the fire is frequently retarded, and nothing can

[1] Muller's "Treatise on Artillery," 1768, p. 203.

[2] General Sir Howard Douglas, "Naval Gunnery," 1860, p. 458. Sir Charles Douglas also introduced into his ship (at his own expense) the quill tubes he had invented for naval use, and flannel cartridge cases which at that time were used "for artillery cartridges of all sorts." Captain G. Smith, "Univer. Mil. Dict.," 1779; "Laboratory."

[3] "Artillery Equipment," Colonel F. Miller, *V.C.*, R.A., Pt. II., p. 84. It is uncertain to what extent flint-locks were adopted for the Artillery. "Ammunition," by Sir V. D. Majendie, i. 192.

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be more dangerous than lighted portfires in a battery. . . . I have ever prevented, as much as in my power, the use of portfires."[1]

A percussion tube, invented by Mr. Marsh, of the Royal Arsenal Surgery, was approved for the Navy in 1831: the Artillery was not supplied with a similar tube until 1846.

In 1841 Lieutenant Siemens, of the Hanoverian Army, laid a friction tube before the officials of Woolwich Arsenal, which was tried and, owing to whatever defects, was rejected. Just ten years later Mr. Tozer, of the Royal Laboratory, made the copper friction tube now in use. It was officially adopted in 1853.[2]

In 1860 there were no less than six tubes in the service:—(1) the Common Quill Tube; (2) the Dutch Paper Tube; (3) the Common Metal Tube; (4) the Percussion Tube; (5) the Friction Tube; and (6) the Galvanic Tube.[3]

Time Fuzes.

Nothing can be less satisfactory than Hassan er-Rammah's allusions to igniters, of which he possessed two—the *rose* and the *ikreekh* (اكريخ). The latter word strictly means a duct, channel, or tube;

[1] "Naval Gunnery," as before.

[2] The above facts are chiefly taken from the "Treatise on Ammunition," by the late Colonel Sir V. D. Majendie, R.A., 1867; and the work on "Artillery Equipment," by the late Colonel F. Miller, *V.C.*, R.A.

[3] "Elementary Lectures on Artillery," by Major C. H. Owen and Captain T. L. Dames, Woolwich, 1861.

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but just as we frequently use *fuze* for *fuze composition*, so the Arabs often use *ikreekh* for the composition it contained. Hassan, for instance, speaks of "the sulphur with which one makes ikreekhs."[1] It is quite clear, however, from Reinaud and Favé's Plate II., fig. 24, that the ikreekh was of the nature of a fuze-case. Whether the composition given here in column 1 of Table XIII. was used in the ikreekh or the rose, I do not know. In fact our knowledge of these two igniters may be summed up in the statement that they were used together in the same (incendiary) shell, and that it was the rose which was lighted.[2] The ikreekh possibly contained the fuze composition proper, and the rose corresponded to our priming matter.

Judging from the plates of Kyeser's *Bellifortis* reproduced by Herr von Romocki (i. 169), the igneous projectiles of 1405 were ignited by some slow-burning composition, which was put on the top of the charge, and filled up the loading hole flush with the exterior of the missile. The breech-loading quill fuze of the second Berlin Firebook, mentioned in the section on "Explosive Shell," seems to have been only the abortive proposal of an inventor.

The foregoing Arab and German igniters were for use in machine and hand projectiles, and we now reach cannon fuzes.

[1] Reinaud and Favé, p. 44.

[2] "Quand tu voudras attaquer ton adversaire, mets le feu à la rose," ib., 38. "Tu mets le feu aux roses et tu lances la marmite," ib., 43.

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The first igneous gun-missiles were incendiary, at once hand-grenades and cannon-balls, and were ignited by means of some slow-burning mixture, without a case, which was put into the shell on the top of its charge. When the missile is "neere full (of good corne pouder)," says Bourne, "take some receite of soft fire worke that will not burne too hastily and fill up the rest of the ball."[1] That the fuze-hole was originally placed next the cartridge is shown by Boillot's repeated directions to turn it towards the muzzle[2]—directions which would have been superfluous had it not been previously customary to place it next the cartridge; and by many other indications. By this mode of loading the ignition of the fuze composition was ensured before the projectile left the piece. There was perhaps no absolute necessity for the use of this soft, slow-burning mixture, with incendiary shell so placed; but it was probably found very useful in confining the charge within the missile during flight.

The need of an explosive projectile to blow up earthworks, &c., was more and more felt as time rolled on, and the use of such missiles was clearly impossible with such igniters so placed. But the best way of mending matters was by no means so clear. If an explosive shell was placed in the bore

[1] "Inventions and Devices," 1578, p. 39.

[2] For instance: "Adviserez que le trou d'icelle (the shell) soit du costé de la bouche dudit mortier." *Modelles, Artifices du Feu*, &c., 1598, p. 163.

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with an igniter of soft, caseless composition next the cartridge, there was in the great majority of rounds a burst in the bore. If the shell was reversed, with the igniter towards the face of the piece, either the composition did not ignite and the shell was blind, or the soft composition set back into the shell from the shock of the explosion[1] and again there was a burst in the bore. Furthermore, in firing against works it was before all things necessary that the shell should enter the revetment, &c., before it exploded, and it was extremely difficult in practice to put into the shell the exact amount of composition that would burn just longer than the time of flight. To prevent the gases of the explosion from forcing their way into the interior of the shell, it was necessary to have the fuze-hole towards the muzzle when the shell was home. To prevent the soft composition from setting back, and to ensure that it was sufficient in quantity to burn longer than the time of flight, a fuze-case was necessary. To ensure the ignition of the fuze (in its new position) it was necessary to light it from the muzzle just before the piece was fired, and this condition restricted the use of explosive shell for centuries to mortars and (afterwards) howitzers. No one would have dared to thrust a lit match down the bore of a gun which had been loaded with loose powder by means of a ladle, and cartridges were not in general use when the question of explosive

[1] As happened centuries afterwards with Shrapnel's fuzes when cut "short."

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shell arose. Bourne says in 1587: "It is a great deal better for to charge a peace in time of service with a cartredge than with a ladell,"[1] and he presently proceeds to give his reasons for thinking so at great length.[2] In the beginning of the following century, Diego Ufano only allows the use of cartridges when a ladle is not at hand.

Such were the steps of the evolution of the fuze, as partially explained by Hanzelet and Thybovrel in their *Receuil de plusieurs Machines Militaires*, published in 1620: "Le souspirail de l'amorce (the funnel of the priming = the fuze-case) est long . . . et creux. . . . Ainsi ce canal éstant emply de composition lente, il ne permet que le feu se prenne qu'il nait (n'ait) lentement consumé la matière mise audit canal, et par ce moyen le feu ne peut toucher la poudre grainée (the bursting charge) qu'il ne soit arrivé jusques au fond de la ditte grenade. Cela sert pour avoir loisir de la jetter à la main, ou de l'allumer et la mettre dans le mortier ou canon" (l. iv. c. 6).

One of the first indications of a fuze with a case is afforded by a passage in Stow's "Annals" for the year 1543, where he speaks of "hollow shot of cast-yron, to be stuffed with fireworks or wild fire; whereof the bigger sort had screwes of yron to receive a match" (p. 584). Stow was evidently describing something which he did not understand, but his meaning is made clear by

[1] "Art of Shooting in Great Ordnance," p. 13.
[2] Ib., pp. 30, 31.

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Boillot. The fuze-case was a hollow, cylindrical male screw which fitted a female screw in the fuze-hole, and when fixed extended across the cavity of the shell: "En laquelle (the shell) laisserez un trou . . . auquelle ferés faire une viz pour le bien boucher, laquelle sera de la longeur de la grenade" (p. 163). Further on he speaks of the case as "un tuyau de fer blanc ou cuivre . . . bien adjousté au dit trou," and directs it to be filled "bien massif de pouldre sans graine." It was lighted from the muzzle of the mortar by a quick-match or hand-fuze,[1] as Nye directs half a century afterwards—light the fuze first, "and then with great speed give fire to the touch-hole" (chap. v.).

Diego Ufano describes experiments carried on during the latter years of the sixteenth, or the early years of the seventeenth century, with cased fuzes of a new pattern[2] proposed by the (then) Governor of Genappe. The fuze, which was filled with moist powder or one of several mixtures given by Ufano, was placed next the cartridge.[3] The first shell fired burst at the muzzle, the second burst short. Two rounds were then fired from an English 60-pr.

[1] Among the stores detailed by Firemaster T. Wright in his "Perfect Narrative," &c., of his expedition to Jersey, 1651, are found "1000 Fuzes for shels, 600 hand Fuzes."

[2] "Invention die bishero noch nit ist gebraucht worden." *Archeley*, 1621, p. 119. The Spanish *Tratado de Artilléria*, 1613, I have not seen and rely upon the French and German translations, both by J. T. Brey, the former entitled *Artillerie*, &c., the latter *Archeley*, &c. Either of them has been carelessly executed—perhaps both of them.

[3] "La bouche du tuyeau sur la poudre de la charge de la ditte pièces." *Artillerie*, p. 119.

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(*carthaunen*), both of which burst in the air and damaged houses and walls in their neighbourhood. A third shell lodged in the ground at a distance of 250 yards,[1] and on bursting sent its fragments back towards the gun, damaging a guard-room[2] which stood 150 yards in rear of it. The experiments then ceased, on the urgent representations of an Artillery officer about the risk they were all running. The earlier fuzes implicitly referred to by Ufano were doubless the "buses" which, Father Strada tells us, were employed at Wachtendonck in 1588. Their name, buses = tubes or pipes, is sufficient proof that they were fuzes with cases. In his "Gunner," 1628, p. 156, Norton speaks of a "pype primed with slow receipt" for exploding shell. We find the very same word applied to fuzes in Danish official documents in 1644: "piber til Granater," pipes for shell.[3] Writing three years afterwards, Nye, Master-Gunner of Worcester, speaks familiarly of *fuzes* which were conical in shape, for he compares them to "faucets for a spigot."[4] He says: "The match doth ofttimes fail, but fuzes are very certain to give fire."

There were no means of regulating the time of burning of these pipes, which were generally metallic. The composition had a constant (and unalterable) length, corresponding roughly to that required for

[1] "150 schritt" — geometrical paces, I presume: 1 geom. pace = 5 ft.

[2] *Wachthaus.* The French translation has *corps de garde.*

[3] Blom's *Kristian d. IV.'s Artilleri*, p. 277.

[4] P. 63 *bis.*

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the *maximum* range at which shell could be fired. Whatever the range, the oblong bombs were fired with a fuze that burned some fourteen seconds, answering to about 1000 yards range; the spherical grenados with a fuze that burned some twenty seconds, answering to about 2100 yards range.[1] In firing against works, &c., it was essential that mortar shell—and until the siege of Gibraltar, 1779, all shell were mortar or howitzer shell[2]—should not burst before impact. A shell which burst in flight was a shell wasted, but it mattered little whether it burst on impact or a few seconds afterwards.[3] But it was occasionally necessary to use shell against troops, and it was then that the radical defect of the tube became fully manifest. In this case it was desirable that the fuze should fire the bursting charge the instant the shell touched the ground,[4] and this was impracticable with the primitive pipe. While the long fuze was burning down to its end, the explosion might be prevented, or its effects

[1] Pr. Lieut. W. *Ritter von* Breithaupt, *Der Entwicklungsgang und die darauf gegründete Systematik der Zünderwesens*, &c., 1868, p. 18.

[2] "Gegen das Ende des 16 ten Jahrhunderts fiel man darauf, Granaten aus Kanonen zu schiessen. Da aber die ersten Versuche nicht mit gehöriger Vorsicht, und überhaupt mit zu starker Pulverladung angestellt wurden, so misslangen sie, und man behielt die sicherere Art, sie aus Haubitzen zu werfen, bei." Major C. von Decker, *Geschichte des Geschützwesens*, &c., 1822, p. 74.

[3] In firing against buildings, "ist es nicht eben von nöthen auf das Tempo genau Achtung zu geben." Mieth, *Artill. Recent. Praxis*, Leipsig, 1683, lib. iii. c. 34.

[4] In firing against troops, "the fuze must have such a length as . . . to set fire to the powder as soon as the shell touches the ground." "Universal Mil. Dict.," Captain G. Smith, R.A., 1779; "Laboratory."

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might be neutralised in many ways. The shell might be thrown bodily into a pond or the sea;[1] the fuze might be extracted;[2] or it might be extinguished with water.[3] But in the vast majority of cases the explosion of the shell was neutralised in a much homelier and less heroic way; those near whom it fell waited for no command to quit its neighbourhood in all haste.

It was long before any real progress was made in the adjustment of fuzes to burn a certain time, chiefly because the early gunners had no timekeeper. A striking illustration of this fact is found in the *Artis Magnæ Artilleriæ*, &c., of Siemienowicz, published in 1650. Wishing to give his readers an idea of the action of a certain fireball, he explains that it burned in the time one takes to recite deliberately the Apostles' Creed.[4]

The first, so far as is known, who urged the adjustment of fuzes was Sebastian Hälle,[5] in 1596, and he fared as fare most of those who see further than

[1] A Chinese shell was thrown from the deck of one of our vessels into the sea, I forget by whom, in the attack on the Peiho Forts, 1860.

[2] As was done more than once during the dynamite outrages in London some years ago.

[3] At the siege of Gloucester, during the Great Rebellion, a grenado fell near Southgate; "but a woman coming by with a pail of water, threw the water thereon and extinguished the phuse thereof, so that it brake not." Vicars' "Jehovah Jireh," 1646, i. 402.

[4] "Per tempus quo quispiam non festinanter Symbolum Apostolorum recitare possit," p. 174. Watches were invented by Huygens in 1674, and independently by Hooke in 1675. Ball's "Mathematical Recreations," 1892, p. 216.

[5] *Zur Geschichte der Artillerie*, by Hauptmann C. Schneider, in *Oesterreichische Mil. Zeitung*, Wien, 1863, No. 79.

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their fellows. The many failed to see the object which he saw clearly; therefore (they said) the object did not exist, and he was a dreamer. A century after his death, however, gunners began to discover that his dreams were substantial enough; and in 1682 Zeug-Lieut. Buchner dilates upon the advantages of a fuze that will burn *ein gewiss Tempo*[1]—a certain time. The mere fact that there were at least three different kinds of fuze in use towards the close of the seventeenth century—paper, wood, and iron[2]—proves that the search for a serviceable fuze was going actively forward. The excellent plates given by Buchner and Mieth show clearly that their fuzes were bored. In both cases the rate of burning was tested with difficulty, owing to the want of a practical timekeeper. Buchner recommends the use of a pendulum, or very careful beating time (or counting);[3] Mieth alludes to the pendulum, but evidently put little trust in it, for he adds, "The correct time can be only found by trial shell."[4]

By the middle of the eighteenth century we had beechwood fuzes, which were cut. The rate of burning was determined "by burning two or three, and making use of a watch or string by way of pendu-

[1] *Theoria et Praxis Artill.*, Nürnberg, 1682, Part II., p. 62.

[2] "Brände von Holtz, Papier oder Eisen," ib.

[3] "Man das Tempo entweder durch einen perpendicul oder nach einem perfecten und gewissen Tacte erkundigen muss," ib.

[4] "Das rechte Tempo nun zu finden, kan auf keine andere Weise, als aus den ersten Würffen erlernet werden." *Artill. Recent. Praxis*, l. iii., c. 34, p. 45.

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lum."[1] It was observed about this period that when fuzes were cut very short, either the flame failed to reach the bursting charge and the shell went blind, or the thin disc of fuze composition set back into the shell from the shock of the discharge and the shell burst in the bore. To obviate this Muller proposed to provide special fuzes, with a quicker-burning composition than usual, for use at short ranges.[2] This plan was temporarily adopted, for we find that there were three different fuzes in our service in 1779, one that burned an inch in 5 seconds, a second that burned an inch in 4.5 seconds, and a third that burned an inch in 4 seconds. It is evident, however, from a remark made by the Inspector of the Royal Military Academy, Captain George Smith, R.A., in his "Universal Military Dictionary" (from which these details have been taken) that the standard of shell fire in the year 1779 was a low one. "When the distance of the battery from the object is known, the time of the shell's flight may be computed to a second or two." Extreme regularity of burning, then, was not expected: an error of "a second or two" in the time of flight was of trivial importance. But an event happened in Gibraltar in this very year which suddenly raised the standard to a height that no one could have foreseen—the adoption of Captain Mercier's method of shell-fire from guns, with short fuzes. This system ended with the siege; it was never resorted to, probably, outside the gates of

[1] "Treatise on Artillery," 1768, p. 204. [2] Ib., p. 203.

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Gibraltar; and, more probably still, when the siege was over things fell gradually back into the unruffled quiet of routine. But the calm was only momentary, for in 1803 appeared Shrapnel shell, and with them reappeared Captain Mercier's forgotten system of "calculated fuzes."

From the first moment it was beyond all doubt that the ultimate success of Shrapnel could be only assured by the use of what no Artillery then possessed—a thoroughly good time-fuze. Writing to Major (afterwards General Sir Thomas) Downman, R.A., on the 29th Feb. 1804, Shrapnel remarks that in firing at short ranges the fuze composition "gives way into the shell once in ten times,"[1] thus producing a burst in the bore; and as a remedy he suggests cutting all fuzes $1\frac{1}{4}''$ long and then sawing a cut through the bottom of the fuze, in a plane passing through its longer axis, *up to* the desired length. However, notwithstanding all precautions, of the 1090 shell fired during the Woolwich experiments with Shrapnel in 1819, 74 burst in the bore, 71 burst in the butt, and 111 were blind, *i.e.* 23.4 per cent. were failures.[2] No efforts were spared to improve these fuzes or replace them by better ones, and a large number were proposed, or constructed, during the second quarter of the last century. In 1850 there were no less than nineteen time-fuzes in our service:

[1] MS. letter kindly lent to me by Col. F. Whinyates, late R.H.A.

[2] Gen. Piobert's notes, communicated to Prof. Turquem and Capt. Favé, the translators of Gen. C. von Decker's *Expériences sur les Shrapnel*, Paris, 1847, p. 320.

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three of metal and sixteen of wood. Of the latter, ten were Shrapnel fuzes, viz. an 8″, a 5½″, and a 1″ fuze, which were uncut; and seven fuzes which were cut ready for use, and lettered A for .1″, B for .2″, – G for .7″.[1] This medley of fuzes was gradually superseded by a wooden time-fuze proposed in 1849 by an officer who had a genius for ammunition, Captain (afterwards General) E. M. Boxer, R.A., and adopted in 1850. In the final pattern of this fuze, adopted early in 1854, England possessed probably the best fuze in Europe.

TABLE XIII.

Time-Fuze Composition.

	Arab.[2] Late 13th Century.	German.[3] Late 16th Century.	English.[4] Early 17th Century.	Swedish.[5] Late 17th Century.	English.[6] Middle 18th Century.	German.[7] Early 19th Century.	English.[8] 20th Century.
Saltpetre . .	71.43	52.1	69.8	69.85	75.0	72.1	76.4
Charcoal . .	21.43	25.6	12.7	8.5	6.25	10.7	14.1
Sulphur . .	7.14	22.3	17.5	21.65	18.75	17.2	9.5

[1] "Ammunition," by Col. Sir V. D. Majendie, i. 235. The Prussians had a similar series of fuzes about the same time; Breithaupt, *Der Entwicklungsgang . . . der Zünderwesens*, p. 21. On the 21st Nov. 1808, Shrapnel proposed to carry the bored fuzes in canvas bags painted different colours. Ord. Sel. Com., "Shrapnel Shell."

[2] Hasans er-Rammah in Reinaud and Favé, p. 25. This composition was called "priming," and belonged to the "slow receipt" family.

[3] Napoleon III., iii. 275.

[4] Nye, p. 63, *bis*.

[5] Spak's *Öfversigt öfver Artilleriets Uppkomst*, &c., p. 157.

[6] Muller's "Treatise on Artillery," 1768, p. 203.

[7] J. G. von Hoyer's *Allgemeines Wörterbuch*, Tübingen, 1804.

[8] 5″ fuze, official "Treatise on Ammunition."

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Percussion and Concussion Fuzes.

The earliest proposal for igniting the bursting charges of shell by percussion appears to have been made in 1596 by Sebastian Hälle.[1] A similar proposal was made in 1610 by Graf Johann von Nassau in a MS. now in possession of the Royal Library, Berlin (MS. Germ. fol. 4), where two hand-grenades are described which explode on being let fall on the ground. The second differs from the first in having a safety apparatus to prevent premature explosions, but both are based on the same principle as Hälle's : flints and steel so arranged as to strike together on impact with the ground.[2] In 1650 Siemienowicz gives a description (with plates) of similar grenades, without a safety arrangement,[3] which Mieth regarded as "curiosities" specially adapted to hurry those who meddled with them into the next world.[4] Yet Buchner mentions them in 1682,[5] and Anderson in 1691,[6] without any (expressed) misgivings of their danger. We may rest assured that these man-traps were never used on actual service.

The use of percussion powder to ignite the bursting charges of shells was first definitely pro-

[1] *Beitrag zur Gesch. d. Artillerie*, Haupt. C. Schneider, Wien, 1864.

[2] See plate in Romocki, i. 343.

[3] *Art. Mag. Artilleriæ*, &c., pt. i. bk. 4, c. 3. They were called "blind shell" because they gave out no light in their flight.

[4] "Wer ein wenig Vernunft hat und nicht gar tumm ist, wird klar sehen dass dieselbe Invention einen sehr bald in die andere Welt schicken kan." *Artill. Recent. Prax.*, c. xi. p. 13.

[5] *Theor. et Praxis Artill.*, pt. i. p. 68.

[6] "Cutting the Rigging," Proposition iii.

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posed, I believe, by Johann Jürgenson von Trachenfels in 1655;[1] just seven years after Glauber had drawn attention to such mixtures in his *Philosophischen Öfen*.[2] Trachenfels' proposals were never put into practice, and no attempt was made to apply percussion powders to military purposes for more than a century. Fulminating silver, discovered by Berthollet towards the close of the eighteenth century, could not be utilised owing to the violence of its detonation. After Howard's discovery of fulminating mercury in 1800, a number of percussion mixtures were made; but seven years passed before Rev. Alexander Forsyth proposed to use them for the priming of firearms,[3] and eleven years more elapsed before it occurred to Colonel Peter Hawker to enclose percussion priming in a copper cap.[4] The percussion musket did not make its appearance until 1842.

The first English concussion fuze[5] was invented by Quartermaster Freeburn, R.A., in 1846; the first percussion fuze by Commander Moorsom, R.N., in 1850.

[1] MS. in Royal Library, Berlin, q. in Romocki, i. 347.

[2] Cap. 48. [3] See his Patent, No. 3032, 11th April 1807.

[4] We are told by Mr. Greener that "all the gunsmiths in England" laid claim to the invention of the cap: "The Gun and its Development," 3rd ed., 1859, p. 110. How many of them, if any, established their claim I do not know; but it is absolutely certain that the notion of a copper cap struck Colonel Hawker in 1818. He gave a sketch of what he wanted to the celebrated Joe Manton, who made him some caps and adapted a gun for their use. "Instructions to Young Sportsmen," by Col. Peter Hawker, 11th ed., 1859, p. 76.

[5] The concussion fuze was set in action by the shock of discharge; the percussion fuze by the shock of impact with the target.

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CHAPTER XVI

SIGNALS

The following tables tell their own tale :—

TABLE XIV.

Signal Rockets.

	Chinese.[1] 13th Century.	Greek.[2] 13th Century.	Arab.[3] 13th Century.	English.[4] 17th Century.	English.[5] 20th Century.
Saltpetre . .	61.0	69.2	69.5	60.0	61.6
Charcoal . .	18.3	23.0	15.7	25.5	23.0
Sulphur . .	18.3	7.8	14.8	14.4	15.4
Mi-to-sing ? .	2.4	...	...	...	...

TABLE XV.

Fixed Lights.

	Arab.[6] "Light of the Moon," 13th Century.	English.[7] "Light, Illuminating Wrecks, Mark IV.," 20th Century.
Saltpetre	71.4	72.3
Charcoal	15.2	21.0
Orpiment	13.4	6.7

[1] Reinaud and Favé, p. 180. [2] Marcus Græcus, recipe 33.
[3] Hassan er-Rammah in Reinaud and Favé, p. 24.
[4] 1, 2, and 3 oz. rockets in Nye, p. 82.
[5] Signal rocket, official "Treat. on Ammunition."
[6] Hassan, as above. [7] Official "Treat. on Ammunition."

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TABLE XVI.

Fireworks.

	Arab.[1] "Golden Garlands," 13th Century.	English.[2] Tourbillions, 20th Century.
Saltpetre	62.5	58.0
Charcoal	25.0	12.0
Sulphur	6.25	13.0
Steel filings . . .	3.125	4.8
Cast iron borings .	...	12.2
Bronze filings . .	3.125	...

[1] Hassan, in Reinaud and Favé, p. 27.
[2] Kentish's "Pyrotechnist's Treasury," 1878, p. 187, No. 13.

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