Chapter 12

Military Technology
Introduction

Probably in no other domain were the knowledge and achievements of other cultures adopted as quickly as in military technology. The rapid and wide-scale expansion resulting from the conquests by Muslims in the first century after their appearance on the stage of world history leads us to assume—of course not without historical documentation—that they quickly recognized the superior quality of their adversaries’ weapons and appropriated that knowledge.

The adversaries who were initially superior to them included, besides the Byzantines, also the Persians. It is therefore not surprising that the oldest books preserved in Arabic literature on military technology turn out to be translations of works by the Persians of the Sassanid period or by Indians. Moreover, the historian of science Ibn an-Nadμm, who lived in the 4th/0th century mentions an Arabic work on the use of a certain type of Greek fire (Kitāb al-‘Amal bi-n-nár wa-n-naft wa-z-zarrāqāt fi l-hurūb) and a book on battering rams, catapults and ‘military stratagems’ (Kitāb ad-Dabbābāt wa-l-manḍānīqāt wa-l-ḥiyal wa-l-makāyid).

Against such a background we can appreciate better the report of the historian at-Ṭabarī (d. 310/923) to the effect that the Abbasid Caliph al-Mustāṣim had deployed mobile battering rams at the conquest of the city of Amorium (southwest of Ankara) in 213/837 (see above, pp. 137 f.).

Without wishing to overrate the contribution in this field which is due to the Arab-Islamic world in the universal history of science, we must emphasize that the military technology also underwent a significant development in the Arab-Islamic area in the period between Late Antiquity and the so-called Renaissance. It goes without saying that the advances in fields like physics, chemistry and technology, made continuously for centuries since the 3rd/9th century in the Arab-Islamic world, would not remain without an impact on military technology.

In their writings published between 1845 and 1858, Joseph-Toussaint Reinaud and Ildephonse Favé have been able to extract, to a large extent, the contribution of the Islamic countries to the technology of weaponry. The results obtained by them from the study of the manuscripts of Arabic works on military technology which were accessible to them at that time and from information in historical works are to a large extent valid even today. Moreover, a few other important manuscripts and historical data that have in the meantime become available take us further. The results achieved by Reinaud and Favé and the views they held on the Arab-Islamic world in the history of military technology were taken into consideration rather well in the non-Arabist studies on the subject in the second half of the 19th century and the first half of the 20th century. On the other hand, it is striking that in studies from the second half of the 20th century onwards hardly any of it was taken note of, with the exception of the commendable History of Greek Fire and Gunpowder by J. R. Partington (1960), the relevant parts of Science and Civilisation in China (vol. 5, part VI, 1994) by Joseph Needham and Zur Geschichte des mittelalterlichen Geschützwesens aus orientalischen Quellen by Kalervo Huuri.

3 Fihrist, op. cit., p. 315; J. Reinaud, De l’art militaire, op. cit., p. 196.
As I now undertake to discuss some new elements which, in my view, were developed or discovered in the military technology of the Arab-Islamic world, I restrict myself at this point to the large crossbow, the counterweight trebuchet, gunpowder and firearms. These are elements which appear as new inventions in the history of European military technology in the 13th or the 14th century.

a) Windlass Crossbow

Of the diverse types of the crossbow which already formed part of the artillery of the Greeks, Romans and Sassanid Persians, I mention here only the windlass crossbow which was drawn through a windlass (rack-and-pinion gear). This crossbow, which is a variant of the large crossbow (qaus az-ziyār), is described in detail and illustrated in the book In the extant Tabširat arbab al-albāb fī kašfa li-an-naqāt fī l-ḥurāb by Marḏi b. ‘Ali b. Marḏi aṭ-Ṭarsūsī, which was partly edited and translated into French by Claude Cahen in 1948. The bow was called qaus bi-l-laulab. Its description in this book, which was written under Salāḥaddīn (Saladin, ruled 569/1174–589/1193), gives the impression that it was a well known weapon even at that time. It is also listed by the historian Ibn aṭ-Ṭuwair (b. 524/1130, d. 617/1220) among the weapons in the arsenal of the youngest Fatimid Caliph in Egypt of 467/1071. According to his statement, an arrow weighed about 2200 grams. The French historian Jean de Joinville reports that during the crusade of Louis IX in 1249 the Egyptians had shot at the French near Mansūra, among others, four times from the windlass crossbow with Greek fire.

The description of our Arabic sources confirms G. Köhler’s assumption that the windlass crossbow was a normal crossbow which differed only in its larger dimensions from the stirrup crossbow [Arabic qaus al-yad] and was tautened by a windlass (tour) [Arabic laulab]. We can well imagine that it was this type which Emperor Frederick II in 1239 ordered a captain who was sailing to Acco to purchase there tres bonas balistae de torno et de duobus pedibus (Arabic qaus al-‘aggār). In the above-mentioned Arabic book on military technology dedicated to Prince Salāḥaddīn (Saladin) a crossbow with large dimensions is described in quite some detail. If I understand the author correctly, he is of the view that it was an achievement of his older contemporary Abu l-Ḥasan al-Abraq al-Iskandarānī. Claude Cahen, who edited the text, translated it into French and examined it, also understands the author’s statement in the same sense and, based on this, refutes the view of Kalervo Huuri, who claimed that the Mongols had brought the [95] Chinese pedestal crossbow to Persia in the 13th century. The fact of the matter was the other way round, with the Mongols borrowing this improved crossbow from the Muslims. According to the description of the book, that large crossbow (qaus az-ziyār) is said to have been the largest in its dimension, the farthest in its range and the most lethal in its effect. The edges of the square gun carriage are said to measure about 5.6 metres.

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10 v. G. Köhler, op. cit., p. 175.
11 Tabširat arbab al-albāb, op. cit., p. 106.
12 op. cit., p. 129.
14 Cahen (op. cit., p. 151) says: «Kalvero Huuri, n’ayant rencontré d’allusion certaine au qaus az-ziyār que dans des auteurs postérieurs à l’apparition des Mongols, considérait cet engin comme apporté par eux. Notre chapitre nous oblige à adopter une conclusion contraire, et à considérer cette arme comme née au plus tard sous Saladin, et par conséquent vraisemblablement apprise des Musulmans par les Mongols lorsqu’ils la trouvaient employée chez eux. K. H. avait relevé un certain nombre de mentions du ziyaar dans d’autres auteurs contemporains de Saladin (...), mais pensait que le mot avait un sens vague; nous sommes en droit de conclure qu’il avait dès lors son sens précis et que l’arme figure donc normalement dans les guerres contre Saladin et les Croisés entre 1187 et 1192, période à laquelle se réfèrent toutes les citations.»
For operating it a team of about 20 persons was actually needed, but thanks to the technology used, one single man was sufficient to set it in motion. Its technical equipment included a windlass construction for drawing the bow. The length of the parts of the bow lying to the right and to the left of the shaft was about 3.3 metres each. The bows were made of several layers of thin plates of oak wood and animal horn which were sawn into shape and glued together.

The strength of the bow amounted to about 35 cm in the large crossbows, about 4 cm in the medium pieces and about  cm in the small ones. The author states that the number of bows can be increased up to three and demonstrates this with the following illustrations (see fig. on the right above): This type of large crossbow seems to have inspired the imagination of Leonardo da Vinci to think of a gigantic construction.

From the Islamic world a wooden bow with a length of about 2 metres is preserved in the Musée de l’Armée (Hôtel National des Invalides) in Paris, which institution kindly provided us with the following illustration. The bow is said to come from Syria and belongs to the 6th/12th century (see ill. p. 96). Composite bows (laminated with wood, horn, sinews and glue) had been the preferred weapons for hunting and warfare in the Middle East since pre-Islamic times. It is therefore unlikely that to this method of construction was only restored for the bows of very large crossbows. Moreover, there is the possibility that the smaller crossbows contained bows of steel. Our 12th century source is silent on this count but its illustrations create the impression that the smaller crossbows must have been of metal (steel in our case). The earliest mention known so far of a steel bow goes back to the first half of the 8th/4th century. The anonymous source dating from that time enumerates the steel bows as «Indian bow» (qis¬y hind¬ya) in a list of weapons indispensable to the army. It is likely that bows of Damascene steel were meant by this. We learn about the earliest known use of steel bows in Europe from an inventory dating from 1435.

\[\text{References:}\]
\[\text{17} \quad \text{Leonardo da Vinci. Das Lebensbild eines Genies, Wiesbaden and Berlin: Emil Vollmer 1955, p. 291.}\]
\[\text{19} \quad \text{K. Huuri, Zur Geschichte des mittelalterlichen Geschützwe sens, op. cit., pp. 120, 208.}\]
\[\text{20} \quad \text{G. Köhler, Die Entwicklung des Kriegswesens, op. cit., pp. 181-182.}\]
b) Counterweight Trebuchet

In his attempt to explain the progress in the technology of weaponry which gradually took place in Europe in the 7th/13th century, G. Köhler in 1887 argued with regard to the new artillery system of that time: «However, at the beginning of the period we encounter the Arabs everywhere as those who have the most experience in things of this kind.» But he thought it necessary to remark: «Although it is very likely that the Byzantines were the inventors of the new machines and that the Arabs adopted these new machines from them, the Byzantine influence cannot be proved in this case.» In the following passage he explains the innovation of ballista with counterweight used since the beginning of the 7th/13th century as compared to the catapults already known to the Greeks and the Sassanids: «The human strength applied to the short lever in the case of the Petraría is replaced by a counterweight, due to which not only is the operating team reduced but the initial velocity of the projectile is also increased considerably, because the falling counterweight attached to the short lever arm increases its speed as a consequence of the velocity of fall, and this is also transmitted to the projectile on the long arm of the lever.»

In the course of his rather detailed treatment of the subject, Köhler expresses the assumption that this piece of artillery reached Europe via Italy and the Spanish Arabs. Compared to the much more extensive material on the European side until the middle of the 20th century researchers did not have many Arabic sources at their disposal. For a chronological evaluation of counterweight trebuchets used in both Europe and the Arab world, to judge from illustrations and descriptions, [97] it was primarily the book on the military technology by the Mamluk tournament master Hasan ar-Rammāḥ (d. 694/1295) which since 1845 has offered (see below, p. 99) a terminus a quo or ad quem.

The book, which was dedicated to the ruler Saladin in the second half of the 6th/12th century, and which was partly edited by Claude Cahen in 1948, gives us short descriptions of various types of catapults, an «Arabic one», a «Persian or Turkish one» and a «Byzantine or Frankish one». The most reliable was the Arabic catapult, the easiest to use was the Turkish variety. Unfortunately the descriptions are very brief and do not permit an exact idea of details. Among the illustrations added in profile, the form of the beam of a counterweight trebuchet is remarkable. On the other hand the book offers a complete pictorial depiction of a «Persian» counterweight trebuchet which served as a crossbow and at the same time as a catapult. It is a very advanced type. The brief description and the illustration of parts of the catapult known as «Byzantine or Frankish» give the impression of a projectile with small levers.

Clearer illustrations of counterweight trebuchets are provided a century later by the Mamluk tournament master Nağmaddin Hasan ar-Rammāḥ (d. 694/1295, see below p. 99). More advanced versions of this type appear in the al-Anqīl-manāqīn by Ibn Aranbuğā az-Zaradkāš (written 775/1374). This author, who was in the service of the Mamluks,

22 ibid., p. 190.
23 ibid., p. 194.
24 ibid., pp. 195-196.
25 cf. the remark by Cl. Cahen on the text of the Tābṣirat arbab al-albāb, op. cit., p. 158.
gives illustrations of two highly advanced forms of the counterweight trebuchets. He calls one of these qarābuγā ('black bulls'). It served for hurling heavy stone balls and was provided with a degree-meter for regulating the range and for calculating the aim, and also with a block and tackle and a windlass for increasing its effectiveness.

After these brief remarks on the origin and development of counterweight trebuchets, we may draw attention to some reports on their dissemination outside the Islamic world as well.

K. Huuri26 compiled some information on the quite early use of the counterweight trebuchet in Europe at the beginning of the 7th/13th century. He also refers to several European sources in which the very advanced type is mentioned27 at the siege of Acre (‘Akkā) by the Muslims in 1291 as a large sensational machine under the name caraboga (caabouhas, carabaccani); on this weapon more details are available now in the book by Ibn Aranbuγā az-Zaradkāš. According to Arabic sources, 92 (or more) stone catapults (manγaniq) were employed at the siege.28 Of great importance in this connection are doubtless the reports of the Chinese and Persian sources on the question when and how the type of the large counterweight trebuchet reached the Chinese. It is reported that Kublai Khan, the grandson of Genghis Khan and founder of the Eastern Mongol empire, encountered bitter resistance at his attempt, begun in the year 1268, to take Sūŋ-China. He encountered this resistance particularly at the siege of the two northern, strategically important, cities of Hsiang-Yáng and Fán-Chéng. At the suggestion of one of his commanders, Kublai ordered two engineers (from the West), from the Arab-Islamic territories, to be fetched with the order to build large counterweight trebuchets. With the help of the machines built by these two engineers, I-Ssû-Mã-Yín (Arabic Ismā‘il) and À-Lào-Wā-Ting (Arabic ‘Ala‘addin), Kublai succeeded in conquering the two cities in 1272 and 1273, and thus the Mongols secured their rule over China. The trebuchet introduced in this manner into China was called huí-huí («Muslim») pháo.29

[98] Chêng Ssû-Hsiao, a contemporary chronicler wrote the following about this: «The [Mongol] bandits used Muslim trebuchets against the city of Hsiang-Yáng, whose towers and walls they destroyed with alarming effect, so that [the governor and commander] [Lû] Wén-Huàn was very concerned … The type of «Muslim trebuchet» originally came from the Muslim countries. It was stronger than the common trebuchets. In the case of the largest of them, the wooden frame stood over a depression in the ground. The projectiles measured several feet in diameter. When they fell to the ground they made a hole three or four feet deep. When [the artillerists] wanted to shoot over a large distance, they raised the [counter] weight and pulled it further back [on the stock]; when they had a shorter aim, they put [the weight] further to the front, closer [to the fulcrum].»30 In conclusion, it may be mentioned that Leonardo da Vinci left behind a remarkable sketch of a counterweight trebuchet (see our model below, p. 119).31 There he puts a wheel around the axis of the beam, which seems to fulfil the function of a distance regulator. D. Hill32 drew attention to this sketch. J. Needham33 takes the view that Leonardo heard about the trebuchet via Mariano Taccola34 (d. ca. 1458). In my opinion, however, Leonardo’s sketch is far removed from Taccola’s account. His distance regulator and the beam strengthened with several bundles of rope are reminiscent of an Oriental model.

27 ibid., pp. 174-175.
30 J. Needham, op. cit., p. 221.
33 Science and Civilisation in China, vol. 5, part 6, pp. 204-205.
c) Fire Arms

In the first decade of their expansion when they laid siege to cities, Muslims made use of catapults (mangāniq) inherited from the Sassanids or the Yemenites,15 likewise they did not fail to make use of the ‘Greek fire’ which they had taken over from the Byzantines. It is recorded that at the siege of Constantinople in 97/715 they used the pyrotechnical effect of naft (naphta).16 As was already mentioned (see above, p. 94), an Arabic book on Greek fire was written in the early Abbasid period, certainly before the 4th/10th century.

To be sure, for this effective weapon, which was used for centuries not only in the Arab-Islamic world, different formulas were developed in the course of time. About a rather elaborate composition from the 13th century, we are informed by the Liber ignium ad comburendos hostes,17 which probably originated at the end of the century. The little booklet, preserved in Latin and containing about 6 pages, is ascribed to a certain Marcus Graecus and consists of a collection of formulas without any recognizable order.18 According to J. R. Partington,19 the author was a ‘Jew or Spaniard’ of the 12th or the 13th century.20 The main formula of the Liber ignium consists of ‘pure sulphur, cream of tartar, Sarcocolla (the resin of a Persian [99] tree of the same name), pitch, sodium chloride and paraffin (naphta), besides common oil.’21 From the most advanced formula of the Liber ignium, the knowledge of saltpetre and gunpowder can be deduced. However, saltpetre is not mentioned in connection with Greek fire, but leads ‘in combination with sulphur and coal to real gunpowder’, and this is restricted to the ‘manufacture of the rocket and the cannon cracker.’22

On the approximate date and the value of the little book for the history of science, Joseph-Toussaint Reinaud and Ildefonse Favé covered the essential points in their studies23 published in 1845 and 1849. They were able to refer to a wealth of historical reports from Arabic, Persian and Chinese sources, above all to the book on military technology by Hasan ar-Rammāḥ (d. 694/1295) which is preserved in different editions with the title Kitāb al-Fu’ūsīya wa-l-manāṣib al-ḥarbiyya.24 Reinaud and Favé came to the conclusion that the date or origin of the Liber ignium should be adduced as between 1225 and 1250.25 After many years of study of the subject, the two scholars reached the following conclusion on the question of the origin of firearms: ‘In Antiquity the Greeks and the Romans used certain materials for burning, the composition of which was, however, restricted to very simple formulas. The military art of fireworks, which was made use of by the Byzantines in late Antiquity and which did them at first the greatest service, had been improved remarkably, but the final improvements seem to have come from the Chinese. At least this much is beyond doubt, that the Chinese were the first to recognize that substance which was to change the production of incendiary material, namely saltpetre. When the Arabs took over from the Chinese a certain number of incendiary materials, they learnt from them how to mix the three substances which constitute gunpowder: saltpetre, sulphur and coal.’26 Their progress in the field of chemistry or at least in its application had made it possible for the Arabs to improve the purification of

18 Partington, op. cit., p. 58.
19 ibid., p. 60.
20 Partington (p. 60) says: ‘[Henry V. L.] Hime thought that the author or translator was not a Greek or Muslim (who never used the name ‘Greek fire’), but a Jew or Spaniard who either did not know the Latin names for some Arabic words or thought them so familiar that they need not be translated (alikutran and zembac are untranslated; the Arabic nihās ahpbr for copper becomes aes rubicundus not cuprum, …).’
22 Partington, op. cit., p. 59.
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26 ibid., p. 169.
27 Histoire de l’artillerie. 1ère partie: Du feu grégeois, des feux de guerre et des origines de la poudre à canon, Paris 1845
28 cf. C. Brockelmann, Geschichte der arabischen Litteratur, 1 suppl. vol., p. 905; ed. by ‘Id Daif al-‘Abbādi, Baghdad 1984
saltpetre considerably.⁴⁷ According to Reinaud and Favé, the Chinese discovered saltpetre and were the first to use it for the manufacture of fireworks. They were also the first to mix this substance with sulphur and coal to recognize the propulsion power produced by burning the mixture. This led them to the idea of constructing rockets. As far as the Arabs are concerned, they had recognized the explosive power of gunpowder, used it, and had thus invented firearms⁴⁸ Despite the observation that the Chinese had known saltpetre and its explosive character even before the 13th century, the question still remains as to whether the Arabs owe this knowledge to the Chinese or whether it is an independent development on their part. Until now the discussion of the subject started from the assumption that saltpetre, the main element of gunpowder, was unknown before the 13th century in the Arab-Islamic world. The discussion relied primarily on the earliest mention of saltpetre outside China, namely in the book of simple remedies (al-Ǧāmiʿ li-mufradāt al-adwiyah wa-l-aḍāiya) by ʿAbdallāh b. ʿĀhmād Ibn al-Bailār⁴⁹ (d. 646/1248) where it is mentioned that the substance was known by the name of bārūd among the scholars of the Maghrib.

[100] However, we learn from a quotation in the history of medicine by Ibn Abi ʿUṣaiʿī[a (d. 668/1270) that the physician ʿAbdallāh b. ʿĪsā Ibn Baḥtawah (d. ca. 420/1029) described in detail the use of saltpetre for the manufacture of artificial ice in his book Kitāb al-Muqaddimāt or Kanz al-attibāṭ.⁵⁰ E. O. von Lippmann pointed this out in 1906.⁵¹

The earliest mention in Arabic writings known so far of the use of saltpetre for the manufacture of gunpowder was identified by Reinaud and Favé⁵² (middle of the 19th century) in the Paris manuscript of the book by Hasan ar-Rammāḥ (d. 694/1295). They also found the description of a cannon and a gun (see below, p. 133) in the manuscript of an important anonymous book on the art of warfare (al-Maḥzūn fi ǧamīʿ al-funjūn), preserved at St. Petersb.⁵³ This convinced the two scholars that the discovery of the propulsion power of gunpowder had taken place in the Arab-Islamic world. They had to revise their opinion that the place where gunpowder was first used is said to have been in Eastern Europe, in the region along the Danube.⁵⁴ On the basis of the Petersb. manuscript, Reinaud and Favé came to the conclusion that the power of propulsion of gunpowder must have been known in the Arab-Islamic world at the latest in the second half of the 8th/14th century and this conclusion was confirmed by the Kitāb al-Anīq fi l-ṭanāfṣīq by Ibn Aranbaughaz-Zaradkāš (written in 774/1373), the manuscript of which was discovered subsequently. This illustrated manuscript, preserved in the library of the Topkapi Sarayi (Aḥme III, 3469),⁵⁵ contains illustrations of quite advanced types of cannon. Of course, neither the lifespan of Ibn Aranbaughaz-Zaradkāš nor the likely date of composition of the anonymous Kitāb al-Maḥzūn

⁴⁷ ibid., p. 261.
⁴⁸ Reinaud and Favé, Du feu grégeois ... (1849), op. cit., p. 327.
⁵² v. particularly Du feu grégeois ... (1849), op. cit., p. 261 and De l’art militaire, op. cit., p. 200.
⁵³ Current shelf mark number C 686, see A. B. Chalidov, Arabskie rukopisi Instituta Vostokovedenija, vol. 1, Moscow 1986, p. 493.
⁵⁵ v. H. Ritter, La Parure des Cavaliers und die Literatur über die ritterlichen Künste, in: Der Islam 18/1929/116-154, esp. pp. 150-151. The date on the title page of the manuscript is erroneous; the book was dedicated to Mängli Buğā (d. 782/1380); son fol. 58b and 126a there is a colophon each of 21st Ram. 774, fol. 181b one of Ǧum. II 775w (Ritter).
M L I T A R Y  T E C H N O L O G Y

(8th/14th c.) can serve as the upper limit of the emergence of the first firearm. Both authors, like their predecessors and successors, recorded in their respective books the knowledge of their times and of their geographical regions. They were not concerned with the question of the origin and the time of appearance of the objects, but with the description of the state of affairs as it was known to them at that time. Consequently the manuscript of the book by Ibn Aranbu∫® with its date 774/1372 gives us a terminus ad quem, not a terminus a quo for the origin of firearms in the Arab-Islamic world.

The earliest reference to date to the use of a firearm in the Arab-Islamic world is to be found in connection with the siege of the city of Siġilmása in 672/1273. The well-known historian Ibn Haldûn reports in his historical work that against Siġilmása the Merinid Sultan Ab' Y'suf Ya'q'ub (ruled 762/1362−685/1286) had employed man®™n¬q (counterweight trebuchets), ‘arrâdât (crossbows) and hindâm an-naft, a weapon where iron bullets were discharged out of a «magazine» (ḥijâna) after igniting the gunpowder.66 Reinaud and Favé, who were the first to draw attention to this statement, doubted its veracity [101], primarily because it was not confirmed by contemporary sources.67 As reported by Lisânaddn Ibn al−øafl¬b in his 1955, p. 398; E. Quatremère, 724/1324, the Nasrid Sultan Abu l−Wal¬d Ism®'¬I (ruled 713/1314−725/1325) bombarded the fortress of Iškar (8th/4th c.) can serve as the upper limit of the origin of firearms.


The information by Ibn al-Ḥaṭîb attracted the attention of scholars even in the 18th century. The Spanish orientalist M. Casirî59 translated it into Latin. From him it was taken over, among others, by the historian José Antonio Conde60 (1765−1820). In Casirî’s reproduction of the passage the word «iron» is missing, probably as a consequence of the manuscript used by him. That was one reason why a number of scholars wondered whether Ibn al-Ḥaṭîb could really have meant a cannon61 or whether it could not have been a large trebuchet instead.62 Some reports in Spanish chronicles give information about the firearms used in the battles between Christians and Muslims in the years 1331, 1340 and 1342.63 I shall let G. Köhler64 make the concluding remark on this subject: «These statements have to be understood in the context of Arabic literature in order to conclude that since 1325 they actually refer to firearms and that the Arabs are the ones who introduced them to the Occident.»

72 Die Entwickelung des Kriegswesens, op. cit., p. 70.
76 Die Entwickelung des Kriegswesens, op. cit., p. 223.
77 Die sphärisch-konischen Gefäße aus gebranntem Ton, in: Zeitschrift für historische Waffen- und Kostümkunde (Dres-


The information by Ibn al-Ḥaṭîb attracted the attention of scholars even in the 18th century. The Spanish orientalist M. Casirî59 translated it into Latin. From him it was taken over, among others, by the historian José Antonio Conde60 (1765−1820). In Casirî’s reproduction of the passage the word «iron» is missing, probably as a consequence of the manuscript used by him. That was one reason why a number of scholars wondered whether Ibn al-Ḥaṭîb could really have meant a cannon61 or whether it could not have been a large trebuchet instead.62 Some reports in Spanish chronicles give information about the firearms used in the battles between Christians and Muslims in the years 1331, 1340 and 1342.63 I shall let G. Köhler64 make the concluding remark on this subject: «These statements have to be understood in the context of Arabic literature in order to conclude that since 1325 they actually refer to firearms and that the Arabs are the ones who introduced them to the Occident.»

d) Grenades and hand grenades

The sphero-conical vessels unearthed in archeological excavations in Central Asia, in Persia and in the Volga region were considered for a long time to be architectural ornaments, containers of quicksilver or holy water, or even lamps. That they are grenades and hand grenades is an idea which began to only gain ground towards the end of the 1920s. The pioneer of this new interpretation was Wsewolod von Arendt.65 The vessels, large numbers of which
are preserved, show unusual strength and have a strikingly thin neck. Some specimens found in Syria carry inscriptions like *fath – fath* («victory – victory»), *bi-Ḥamā« in [the city of] Hamā» or blessings.

Referring to the places where these grenades originated from or where they were found, Arendt says the following: «We encounter the form of the spheroid-conical vessels throughout the Muslim East.»

«Indeed, Islam confronts us as a factor in the dissemination of this object which Islam employed in its victorious march as a weapon of war until it is superseded by firearms.»

[102] According to Arendt’s conjecture, those vessels contained both incendiary materials like «Greek fire» and explosives: «There is no doubt about the explosive power of the contents of the grenades; this is attested by the fragments of these old fortresses. Therefore we cannot consider the old clay grenades as mere incendiary projectiles. Their effect would have been too little for Asian cities and fortresses, which had too little inflammable material.»

«That almost all the vessels are provided with a neck which has a narrow part allows us to draw conclusions about the way the grenades were thrown. The narrow part seems to have been intended to be encircled by a fine cord. It is quite likely that the grenades were carried during the campaign on a cord which encircled the neck of the vessel and whose other end was fastened to the belt or the saddle and that the cord was then used for throwing.»

«The grenade may have been hurled with a circular sweep, with the cord playing the role of a sling, which must have enhanced the flight range of the grenade.»

Arendt was able to base his research on the material at his disposal in the Historical Museum in Moscow. He assumed that there was a connection between this material and the type of grenade found in Damascus, which was known to him indirectly. He dated the vessels, richly decorated with ornaments, between the 7th/13th and the 8th/14th centuries. He regretted that he did not succeed «in analyzing the minute parts which could be taken out of the vessel.»

Arendt’s wish was fulfilled in the subsequent decades thanks to the efforts of Maurice Mercier. As a French naval officer in Syria he had, since 1916, been in frequent contact with the curators of the Cairo museum and had secured possession of a number of such vessels which had been found during archeological excavations in the old part of Cairo. In the course of his examinations he was convinced that the specimens found in Cairo belonged to the weaponry used by the Egyptians at the siege of the city by Amalrich I in 1168. For this conclusion he relied on the report of the historian al-Maqrizi, according to which Şawir b. Muğir as-Sa'di, the governor of Upper Egypt (d. 564/1169), had sent 20,000 *qārūrat nafīfi and 10,000 maṣ'al nār* to Cairo on that occasion. He makes a distinction between grenades with gunpowder and those with liquid incendiary material. He found both these varieties in the above-mentioned (see above, p. 94) defences of al-Mansūra against the army of Louis IX in 1249.

Chemical analyses which Mercier commissioned of preserved grenades of Cairo, Alexandria, Jerusalem, Damascus and Tripoli (in modern Lebanon) convinced him—of course not without the support of historical evidence—that the knowledge of the Arab-Islamic countries regarding saltpetre goes back to a considerably earlier period than is generally supposed. In 1937 he published the result of

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66 ibid., p. 209.
67 ibid., p. 209.
68 ibid., p. 209.
69 ibid., p. 209.
70 He recorded his results in his *Le feu grégeois. Les feux de guerre depuis l’antiquité. La poudre à canon*, Paris 1952.
71 ibid., p. 94.
73 M. Mercier, op. cit., pp. 98 ff., 104, 125 ff.
he calls attention to the fact that only in rare cases was incendiary material found in the specimens preserved. A chemical analysis had shown disappointing results in this respect, adds Seyrig. With regard to his last objections, it must be remarked that he does not seem to have read Mercier’s book completely. It also seems that Seyrig to a certain extent contradicts the content of his own footnotes, which are related to this question. Seyrig also asks us to bear in mind that many grenades are decorated and that some of them carry blessings or messages of congratulation.

The answer of the adherents of the grenade theory «that some people decorate their arrows» failed to convince him. Without repeating his arguments here, we may say that most of the incendiary projectiles depicted in Arabic books on military technology are lavishly decorated, as in those by Ḥasan ar-Rammāḥ (MS Paris) or Aranbuğa az-Zaradkāš (MS Topkapı Sarayi). Among the «three hypotheses» known to him, Seyrig tends to favour that of the aelopiles or wind-balls (aeolipila). This steam blower is «a metal ball with a fine opening, which is filled with water and then put into fire in order to show the violent blowing of the steam». The aelopile was already known to Heron and Vitruvius. In his article of 1951, W. L. Hildburgh wonders whether our vessels of burnt clay could not be a type of aelopile. [104] Then, in 1965, Richard Et-

[80] ibid., pp. 94, 126.
[81] ibid., p. 85.
[82] Le feu grégeois, op. cit., pp. 85.
[83] ibid., p. 84.
[84] ibid., p. 85. He is referring here to Fr. Sarre (Das islamische Milet by Karl Wulzinger, Paul Wittek, Friedrich Sarre, Berlin and Leipzig 1935, p. 76) who emphasizes «that it is particularly in accordance with the character of Islamic creativity to decorate an object without taking into account whether its decoration will be noticed or not. Often the invisible underside of an instrument of metal is decorated in the same rich style as the visible side.» See also the earlier explanation by Fr. Sarre, Keramik und andere Kleinfunde der islamischen Zeit von Baalbek, in: Baalbek. Ergebnisse der Ausgrabungen und Untersuchungen in den Jahren 1898 bis 1905, vol. 3, by H. Kohl, D. Krencker, O. Reuther, Fr. Sarre, M. Sobernheim, Berlin and Leipzig 1925, pp. 133-135.
[85] ibid., p. 86.
tinghausen\textsuperscript{93} took up the subject from the point of view of art history. After the «sound objections» from Henri Seyrig, as he says, he himself now began to view with doubts the explanation of the vessels as hand grenades. Among other things, he points to one of the objections raised by Seyrig, namely the appearance of blessings like the bas-mala on the vessels.\textsuperscript{94} Among the interpretations known to him, he considers that by E. von Lenz\textsuperscript{95} to be the most likely one, although it was not the only possibility.\textsuperscript{96} Lenz had opined that the vessels could possibly be containers for quicksilver. However, Ettinhausen does not commit himself to any one interpretation and expresses the hope that the study of manuscripts, chemical examination and aerodynamic trials might bring clarification in future.\textsuperscript{97} Unfortunately he does not seem to have known the results of the chemical analyses recorded by M. Mercier. The most recent study on the subject known to me at this moment carries the title \textit{A sphero-conical vessel as fuqqāʿa, or a gourd for «beer»} and is by A. Ghouchani and C. Adle.\textsuperscript{98} From this article we learn more than we had known to date about the widespread usage of the word fuqqāʿa in Arabic-Persian literature in the sense of a drinking vessel. But the two authors also emphasize quite rightly the possibility that a fuqqāʿa can also have served for other purposes.\textsuperscript{99} They give photos of a number of vessels with the inscription isrāb hāniʿan («to your very good health!») and refer to them as sphero-conical vessels characterized by a «thick body, narrow opening, and short neck.» But not all of them have a sphero-conical form and the characteristics mentioned. In my opinion, the authors disregard one of the most important characteristics. The objects which we might consider as grenades are actually tapering to a point at the bottom so that one cannot put them upright without a support. No doubt, vessels of burnt clay designated as fuqqāʿa were used for various purposes, depending on the shape and size.\textsuperscript{100} Unlike the large specimens which were hurled by machines, the small hand grenades, had a very narrow mouth of about 3 to 5 mm diameter which did not serve for filling the powder, but obviously for inserting the fuse. As we can observe in almost all hand grenades, a groove separates the button-like neck from the bulbous trunk. This leads us to the conclusion about the manner in which such grenades were made. The bulbous lower part was probably made separately in two halves and was joined together only later on. Likewise, the separately burnt upper part with the fuse was probably only joined to the lower part after it was filled with powder. The groove shows the joining of the two parts. Friedrich Sarre\textsuperscript{101} has drawn attention to some casting moulds of stone which were found and described in the 1930s; he reproduced a photo of two such moulds (fig.) They were joined to each other with lead plugs. A chemical examination in Berlin had shown that the stone used consisted of chlorite, which «as a consequence of its low hardness can be worked easily» and which is «relatively resistant to heat».\textsuperscript{105} Sarre’s opinion that these are casting moulds for the manufacture of hand grenades can hardly be endorsed since the preserved stone forms are meant for the shaping of «richly decorated vase-like vessels». Moreover, because of the lead plugs the forms are not suitable for firing in the oven; it is more likely that these were casting moulds for metal or glass.

«One of the stone forms carries an incised inscription with the name «Shech Pasha»».\textsuperscript{102} One type of grenade, called furqāʿa, is described by the Ras’lid king al-Muẓaffar Yusuf b. ‘Umar (d. 694/1294) in his book \textit{al-Muḥṭara fi junūn as-ṣuna}. It consisted of a specially prepared hard cardboard which was

\textsuperscript{93} The uses of sphero-conical vessels in the Muslim East, in: Journal of Near Eastern Studies (Chicago) 24/1965/218-228.
\textsuperscript{94} ibid., p. 225.
\textsuperscript{96} R. Ettinhausen, \textit{The use of sphero-conical vessels}, op. cit., p. 224.
\textsuperscript{97} ibid., p. 226.
\textsuperscript{98} Published in \textit{Muqarnas. An annual on Islamic art and architecture} (Leiden) 9/1992/72-92; see also Edward J. Keall, «One man’s Mede is another man’s Persian; one man’s coconut is another man’s grenade», in: \textit{Muqarnas} 10/1993/275-285.
\textsuperscript{99} A sphero-conical vessel, op. cit., pp. 73,76.
\textsuperscript{100} Emily Savage-Smith also makes this assumption in her attempt to provide a typology of such vessels and in her description of those in the Khalili collection. She rules out the possibility of grenades. See \textit{Sphero-conical vessels: a typology of forms and functions}, in: \textit{Science, Tools and Magic. Part Two: Mundane Worlds}, Oxford 1997 (The Nasser D. Khalili Collection of Islamic Art, vol. 12, part 2), pp. 324-337.
\textsuperscript{101} \textit{Das islamische Milet}, op. cit., pp. 77-78.
\textsuperscript{102} At this point I should like to thank Mrs. Gisela Helmecke (Museum für islamische Kunst, Berlin) for her valuable explanations.
filled with gunpowder and provided with a fuse.\textsuperscript{103} Finally we may refer to an informative passage in the book by Hasan ar-Rammāḥ (MS Paris, Bibl. Nat. 2825) to which E. Quatremère\textsuperscript{104} drew attention more than 150 years ago. In connection with the use of gunpowder (bārūd), the author speaks of «pitchers» (kīzān fiqqā‘) that were «fastened to the tips of lances» (murakkaba ‘alā ru‘ūs ar-rimāḥ). Thus we learn that, when necessary, grenades (after ignition) were also fastened to lances and hurled at the enemy.

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«One of the stone forms carries an incised inscription with the name «Shech Pasha»\textsuperscript{1}. One type of grenade, called furqā‘a, is described by the Rasūlid king al-Muẓaffar Yūsuf b. ‘Umar (d. 694/1294) in his book al-Muḥtara‘ fi funūn aṣ-ṣanā‘. It consisted of a specially prepared hard cardboard which was filled with gunpowder and provided with a fuse.\textsuperscript{2} Finally we may refer to an informative passage in the book by Hasan ar-Rammāḥ (MS Paris, Bibl. Nat. 2825) to which E. Quatremère\textsuperscript{3} drew attention more than 150 years ago. In connection with the use of gunpowder (bārūd), the author speaks of «pitchers» (kīzān fiqqā‘) that were «fastened to the tips of lances» (murakkaba ‘alā ru‘ūs ar-rimāḥ). Thus we learn that, when necessary, grenades (after ignition) were also fastened to lances and hurled at the enemy.

\textsuperscript{103} Ed. M. ‘Īlāhīya, Kuwait 1989, pp. 206-207.
\textsuperscript{104} Observations sur le feu grégeois, in: Journal Asiatique, sér. 4, 15/1850/214-274, esp. p. 246.

\textsuperscript{1} At this point I should like to thank Mrs. Gisela Helmecke (Museum für islamische Kunst, Berlin) for her valuable explanations.

\textsuperscript{2} Ed. M. ‘Īlāhīya, Kuwait 1989, pp. 206-207.

\textsuperscript{3} Observations sur le feu grégeois, in: Journal Asiatique, sér. 4, 15/1850/214-274, esp. p. 246.
Illustr. from: az-Zardkāš, al-Aniq, MS Topkapi Sarayı, Ahmet III, 3469.
The traction trebuchet is designated as the «King’s trebuchet» (*manṭaniq sultâni*) by az-Zaradkâš (ca. 775/1374). Here the required leverage is provided by human power. In our illustration the instrument was constructed in such a way that it was to be operated by ten soldiers. They tautened the ejector arm by pulling on the ropes fastened to rings on the right and on the left.

Our model:
Wood and steel.
Length of the ejector arm: 82 cm.
(Inventory No. G 1.01)

Illustration from:
az-Zardkâš,
al-Ânîq, MS Topkapı Sarayi, Ahmet III, 3469.

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Az-Zaradkāš (ca. 775/1374) knows a particular form of the trebuchet called the «European catapult» (manāniq ifranqi). Obviously here it has to do with the counterweight trebuchet (trebuchium) which the «Franks» used. We may assume that this type of catapult was known as early as the first half of the 13th century in Europe.\(^1\) Az-Zaradkāš mentions that a special feature here is that it can be moved easily to any direction.\(^2\) Two wooden boxes filled with stones produce the counterweight, while the ejecting momentum remains constant.

Illustration from:

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The large catapult, called *qarābuğā* («black bull»), seems to be the highest stage of development of trebuchets which were gradually superseded by cannons from the 9th/15th century onwards. The characteristic features which distinguish it from its equally large predecessors are the use of force produced by the tread-wheel and block and tackle, the use of the protractor for taking aim and the use of a surveyor’s levelling instrument when setting it up. Az-Zaradkāsī\(^1\) describes the function and use of this trebuchet and provides quite precise illustrations of its component parts. He also mentions another type of this large catapult which was called *manṭanīq az-ziyār* (see below, p. 110) and which was apparently quite widespread in the 7th/13th century in the Islamic world.

The trebuchet consists mainly of two supporting frames between which a horizontal beam, i.e. the axis of rotation, is fastened. Around this axis an

\(^1\) *al-Aniq fi l-manāğiq*, op. cit., pp. 66-68.
ejector arm can swing which is divided by the axis of rotation [109] into two parts of unequal length. A wooden box filled with stones is attached to the short end of the ejector arm; the end of the longer arm of the lever has a leather sling for receiving a stone or another kind of projectile. When the long lever arm is pulled downwards by means of ropes, windlasses and tread-wheels, the short arm with the counterweight goes up at the same time and keeps the long arm, which is anchored with a hook, under tension. Then after the projectile has been put in position and the hook released, the counterweight pulls the short arm downwards, the long arm leaps high at the same time and hurls the load, mostly stones or incendiary projectiles, in a high arc towards the target.
Counterweight Trebuchet with Arrow Ejector

This type of trebuchet was a sub-variety of the *qarābugā* already mentioned and was called *az-ziyār* in Arabic. The main difference between the two was that the latter was meant to hurl heavy arrows instead of stones or other voluminous objects. For this purpose the container which served as counterweight and which was filled with stones was replaced by a massive piece of iron. The arrows had flipper-like stabilizers at the end of the shaft. They were shaped in such a way that they could be pulled into a groove at the base of the trebuchet by means of a suitable hook on a rope that was fastened to the ejector arm. Apparently the slope of the groove used to be regulated according to the target. We may assume what [111] *az-Zaradkāš*, the author of

the K. *al-Aniq fi l-manâğniq,* leaves unmentioned, namely, that at the front of the groove a suitable guideway was fastened, perhaps in the form of a bridge, so that the arrow was not pulled too far in the vertical direction.
The direction of the shot of this trebuchet was staggered by 180° compared to that of the other type of large trebuchet.
We do not know at present from when the increased momentum of the counterweight trebuchet began to be employed in the Islamic world for shooting arrows and other projectiles. From the statements in the *Tabsirat arba‘b al-‘albâb* by Mardî at-Tarsûsi (6th/12th c.), it is obvious (see below, p. 121 ff.) that this combination was even known at the time of Şalâhaddin (Saladin).

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Counterweight Trebuchet
with Cross Bow

This war engine is one of those described by the above-mentioned (see above, p. 94) Marđi b. ʿAli at-Ṭarsüsi (6th/12th c.) in his book *Tabširat arbāb al-albāb fi kaifiyat an-naqāṭ* dedicated to the ruler Ṣalāḥaddin (Ṣalā−din). He calls it «Persian counterweight trebuchet» (*maňâniqa fārīšti*) and says that master Abu l-Hasan al-Abraq ad-Iskandarānī had described and drawn the device for him.

Here the windlass is replaced by a double block and tackle. The force needed for lifting the counterweight and for tautening the bow is transmitted by the block and tackle and by the sufficiently long arm of the trebuchet. The trigger simultaneously releases the stone projectile for hurling and the crossbow for shooting.
This type of crossbow, in Arabic qaus bi-l-laulab, which is tautened by one or several windlasses (rack-and-pinion gear), was popular as early as the 5th/11th century in the Arab-Islamic world (see above, p. 94). In the 6th/12th century it was described in detail by Marḍī b. ‘Alī al-Ṭarsūsī in his book on military technology (Tābṣirat arbab al-albāb fī kāfīyat an-naḡār) dedicated to the ruler Salāḥaddīn (Saladin). In our model we mainly followed the illustration provided in the al-Aniq fī l-manāḥiq of the 8th/14th century.

Illustration from:
al-Aniq fī l-manāḥiq.

Illustration from:
Marḍī, Tābsira, MS Oxford, Hunt. 264, fol. 112b.
The view from above seems to include the walls of the tower where this large crossbow is installed.
Large triple Crossbow (Ballista)

Among the various types of crossbows described by Mardi at-Tabrisi (6th/12th c., see above, p. 94) in his book *Tabsiyat arba'a al-albab,* the most elaborate one consists of three large rampart crossbows (*qaus az-ziyr bi-l-laulab*) which could be installed one above the other and tautened with one single windlass and could therefore be operated by a single person alone.

Our model is simplified.

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1 MS Oxford, fol. 80 b; transl. by Cl. Cahen, op. cit., p. 131.
Arab **Counterweight Trebuchets** in Occidental tradition

The advanced form of the catapult, as compared to its predecessor (onager) known from Roman times, which was developed in the Arab-Islamic world, can be shown to have existed since the 6th/12th century on the basis of descriptions, illustrations and citations in sources; and it seems to have been known in the West at the latest in the first half of the 13th century (see above, p. 108). For comparison with the Arabic predecessors there are four models of occidental trebuchets in the Museum of the Institute for the History of Arab-Islamic Sciences; these were prepared by Werner Freudemann around 1990.

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**I.**

A trebuchet reconstructed according to the information given by Villard de Honnecourt (1st half of the 13th c., see above, p. 60). The often published reconstruction sketch by Eugène Emmanuel Viollet le Duc (1814-1879)\(^1\) turned out to be unreliable. Our model was built by W. Freudemann according to improved technical data.

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\(^{1}\) Reproduced, for example, in Rüstungen und Kriegsgerät im Mittelalter by Liliane and Fred Funcken, Gütersloh 1985, p. 54.
Our model:
Hardwood.
Scale: 1:20.
Length of the ejector arm: 62 cm.
(Inventory No. G 1.04)

2.

European trebuchet of ca. 1405, constructed on the basis of an illustration in Bellifortis by Konrad Kyeser of Eichstätt (completed 1405). W. Freudemann improved the model as against the illustration, in order to make it functional.²

² Freudemann points out that a model built strictly according to the illustration could not work, because first «The connecting piece above the chute, which terminates at the left extremity of the guide beam would make the procedure of ejection impossible.» And secondly, «The catapult is much too long. The ropes of the catapult do not run freely under the windlass shafts.» Furthermore, he added necessary details and «adjusted» the proportions, particularly those of the tread-wheels.
One more European trebuchet of ca. 1405. It is also depicted and provided with measurements in Bellifortis (MS Göttingen, fol. 30) by Konrad Kyeser of Eichstätt and was reconstructed around 1990 by W. Freudemann. Moreover, it is of special interest here that the releasing mechanism is clearly discernable in the illustration and could be reconstructed exactly.

Illustration from MS Vienna, Cpv 3069, after Schmidtchen, *Mittelalterliche Kriegsmaschinen*, op. cit., p. 18

4.

European trebuchet, constructed by W. Freudenmann on the basis of the following models: Konrad Kyeser, *Bellifortis* (MS fol. 30 and 77) and one drawing each from Cod. germ. 600, Bayerische Staatsbibliothek, Munich (ca. 1390)\(^1\) and manuscript Cpv 3069 in Vienna.\(^2\)

Illustration from:
Cod. germ. 600,
Bayerische Staatsbibliothek Munich
(ca 1390).

Length of the ejector arm: 100 cm.
(Inventory No. G 1.07)

\(^1\) Bernhard Rathgen, *Das Geschütz im Mittelalter*, Berlin 1928 (repr. Düsseldorf 1957), pp. 626–627, 719, fig. 2.

\(^2\) V. Schmidtchen, op. cit., p. 189, fig. 58.
The drawing of this trebuchet by Leonardo da Vinci has already been discussed above (p. 98). Our model is based on it. It may be recalled here that a distance regulator is used with this piece of artillery as we know it from Arab models at the latest since the 8th/14th century (see below, p. 134). Some progress can be seen here in that the distance regulator in the form of a wheel is attached to the trebuchet.
Fire-pot and *biological* grenade

A fire-pot (*qidr*) with rim, filled with a mixture containing saltpetre, was built primarily for the purpose of explosive effect. It has three small tubes (*ikrīh*) filled with a mixture of incendiary substances and is hurled after ignition from a trebuchet or by means of a lance.¹

Model b) represents an early form of the *B-weapon*, a grenade filled with dangerous animals like scorpions or snakes, which is characterized by numerous small air holes.

GR E N A D E S


Illustration from: al-Maḥṣūn fi ǧāmi‘ al-funūn, MS Leningrad, C686, fol. 146.
Grenades

All illustrations from the Khalili Collection, op. cit., vol. 12.2, pp. 324, 334 ff.
Our models:
Earthenware, brown engobe, fuse.
Height: 10-16 cm.
(Inventory No. G 2.11 -17)
In the Kitāb al-Anīq fi l-manāḡīniq by Ibn Aranbugā az-Zarādkāšī (774/1373) a flame-thrower (ṣandūq [al-]muḥāsaqa) is described which was used in close combat and which could produce a flame the length of a lance. It consists of a longish reservoir of metal for paraffin which is connected through two tubes with a cylindrical nozzle. From this the incendiary material is sprayed with a pump while it is lit by a small igniter.


In the course of his discussion of rockets and projectiles which function with rocket propulsion elements of saltpetre, sulphur and coal, Nağmaddin Hasan ar-Rammāḥ, the famous tournament master of the Mameluk period (d. 694/1295), describes «a device which he calls «moving and burning egg». It is also depicted in the copy illustrated. The text and the illustration (see ill.), particularly when combined with Occidental data which will be provided later, leave no doubt that this is a self-moving torpedo which, though primitive, is fully developed in all the essentials.»

«Two concave sheets of iron… are joined together and made tight with felt so that they form a flattened pear-shaped hollow body (…) which is loaded with naphthalene, metal filings and good mixtures … by the latter phrase Hassan always refers to mixtures having a high content of saltpetre."and is

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1 Kitāb al-Furūsīya wa-l-manāṣib al-harbiyya, MS Paris, Bibl. Nat., ar. 2825, fol. 101b; Reinaud and Favé, Du feu grégeois, op. cit., p. 45, illustrations section, plate II, fig. 32.
In this connection, it is intriguing to note that a fairly simple description of a rocket-torpedo is to be found in Bellifortis by Konrad Kyeser (1405). Even more remarkable seems to be the fact that torpedoes with rockets appear in Bellicorum instrumentorum liber by Giovanni Fontana (1st half of the 15th c.).

Towards the end of the 19th century S. J. von Romocki expressed the view that Fontana followed Hasan ar-Rammah in this matter. In our view, it need not necessarily have been Hasan ar-Rammah’s book which formed Fontana’s source. His book is merely the closest work on the subject known to us at this time which we can use for comparison. There cannot be any doubt about the fact that in the Arab-Islamic world numerous treatises were written on warfare and weaponry, some of which reached Europe, particularly during the Crusades. Moreover, the influence of Arab-Islamic culture on Fontana and other European scholars in respect of weaponry and other technological achievements did not come about by books alone. The Crusades undoubtedly played an important role in this connection.

Cf. also Reinaud and Favé, Du feu grégeois, op. cit., pp. 311-313.

2 Romocki, Geschichte der Sprengstoffchemie, op. cit., p. 236, 240.
Grenades
with chemical war materials

In the Kitāb *al-Aniq fi l-manāğniq* (8th/14th c.) the content of a «pot» (*qidr*) is described, which is put together from various substances, among them opium and arsenic; here «pot» is used in the sense of a bomb or grenade, and the substances are said to have a suffocating effect on the adversary. The bomb was called *al-qidr al-muntin li-l-muḥāsafa*.

It was probably hurled from trebuchets, shot with a crossbow or thrown by hand, as the occasion demanded.

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2 in the manuscript *qidr muntin al-muḥāsafa*.
Ottoman Rockets

The Ottoman engineer Lâgari Hasan Çelebi, under Sultan Murad IV (ruled 1032/1623-1049/1640), was certainly following the Arab-Islamic tradition when he built a rocket with seven small side-fins. The fuel of the rocket is said to have consisted of ca. 50 okkas (ca. 60 kg) of gunpowder. As reported by the contemporary Turkish historian Evliya Çelebi, Hasan Çelebi is said to have demonstrated to the Sultan that he could fly across the Bosporus with his rocket and that he could land with the help of additional wings. What is interesting in this connection is the fact that Ogier Ghislain de Busbecq, who was the Habsburg envoy in Istanbul between 1555 and 1562, reports about attempts at flying under Sultan Süleyman (the Magnificent, ruled 926/1520-974/1566), as John Wilkins (1638) informs us. Detailed information about Ottoman rockets with interesting illustrations is given in his book *Unn al-ğazâ* by the engineer ‘Ali Ağâ, who was active under Sultan Ahmed III (ruled 1115/1703-1143/1730). The length of the rockets built by ‘Ali Ağâ is said to have been 7-8 metres. About their circumference he says that a man could hardly encircle them with his arms.

Since this book was hardly known before now, it seemed appropriate to add a few more illustrations which are of interest for military history and the history of technology.

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3 Manuscript Istanbul, Topkapı Sarayı, Bağdat Köşkü no° 368.
Illustrations from 'Ali Āğa, *Umm al-gazā*, MS Topkapı Sarayi, Bağdat Köşkü n° 368.
Illustrations from: 'Ali Ağā, Umm al-gazā, MS Topkapi Sarayı, Bağdat Köşkü n° 368.
Cannon

In the book *al-Aniq fi l-manāğiq* (8th/14th c.) a cannon with its components is depicted. It belongs to a stage of development which we can follow in the Arab-Islamic world up to the second half of the 7th/13th century (see above, p. 100). The cannon was called *midfa‘* or *mikha‘*. The book *al-Aniq* shows three types which differ from one another in the graduations in their scales of distance. The scale of the first type has a division into eleven (illustration a), that of the second a division into fourteen (illustration b) and that of the third a division into ten, which is once again sub-divided (illustration c).

The graduated mechanism for taking aim is called *qundâq*, a Turkish word which is still used today in the sense of the firing mechanism of firearms. In the brief description it is pointed out that the firing range increases in ascending order.

Our model:
Stainless steel, height: 30 cm.
Barrel height adjustable.
Projectile, length 17 cm.
(Inventory No. G 1.16)
One more illustration from al-Aniq with a clear demarcation of the rifle.

Illustrations from:
az-Zardkāš, al-Aniq,
MS Istanbul, Topkapı Sarayi, Ahmet III, 3469.

Illustration of an early European cannon with an arrow-like projectile, from: Walter of Milimete, De nobilitatibus sapientis et prudentiis regum, ca. 1326; MS Oxford,
Hand firearm

The oldest description of a hand firearm known to us at present is to be found in the above-mentioned (p. 100) Petersburg manuscript. The French translation by Reinaud and Favé of 1849 was, unfortunately, not taken note of in an appropriate manner by the historiography of the technology of weapons. As far as I can see, O. Baarmann is a notable exception in this regard: «The oldest oriental weapons which operated with the chemical mixture of fireworks, namely the fire lance and the madfaa, can be called the precursors of the firearms which spread more and more in Europe in the second quarter of the 14th century; these were pieces of equipment of the simplest kind which were provided with handles for easy handling. For many decades this method of making firearms suitable for handling remained the only kind and still survived for a very long time next to the others which were just developing. Illustration 1 (after the Arabic manuscript from the beginning of the 14th century in the Asiatic Museum in Petersburg,) shows the handling of the last-mentioned short, wooden, mortar-like weapon.» However, Baarmann regards the illustration erroneously as a mortar-like hand firearm, whereas the illustration in the manuscript refers to a cannon; Baarmann was probably influenced by the poor drawing and he does not elaborate the details of the «fire lance» described there. Here it is a case of a combined hand firearm. In the farther end of a lance sufficient space is hollowed out so that a charge of gunpowder can be placed there. The projectile has the form of an arrow or a bolt. The lance is hollowed out from ca. 10 cm from its farther end up to the tip. This and other details of the text made it possible for us to reconstruct the model above.

The illustration of a «fire barrel» preserved from the 15th century, which was in the possession of Robert Forrer in Germany at the beginning of the previous century is reminiscent of this oldest hand firearm from the Arab-Islamic world.²


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ballistic
Gauge

Our model:  
Wood, stained and  
Brass, etched.  
Length: 40 cm.  
(Inventory No. G 1.14)

The book *al-Anîq fi l-manâqiq*¹ (8th/14th  
c.) contains the earli- 
est known illustration  
of a ballistic gauge.  
Such a device, which  
was called *mîzân  
 al-qarîb wa-l-ba’id*,  
was used for the  
adjustment while tak- 
ing aim with counter-  
weight trebuchets.

Illustration from:  
az-Zardkâş,  
*al-Anîq fi l-manâqiq*,  
MS Topkapı Sarayî,  
Ahmet III, 3469.

¹ Ed. Aleppo, op. cit., p. 48–49.
After the counterweight trebuchets of large dimensions had reached a high level of development in the Arab-Islamic world, a special instrument for levelling the ground was used when installing the catapults. The instrument for levelling was called mīzān al-ard¹.

Our model:
Brass, polished.
Height: 32 cm.
(Inventory No. G 1.15)

¹ az-Zardkāš, al-Aniq, MS Topkapi Sarayi, Ahmed III, 3469.
Fortification Towers

In the Kitāb al-Aniq fi l-manāqiq of the 8th/14th century there are several illustrations of fortification towers and fortresses. One of these is shown in our model.

Our model:
Wood, lacquered.
75 × 75 × 75 cm.
(Inventory No. G 2.01)

On the right:
3 illustr. from: az-Zardkāš, al-Aniq, MS Topkapı Sarayı, Ahmet III, 3469.

zahhāfa
(Armoured vehicle with a battering ram)

A report from the early 4th/10th century gives a good insight into military technology, from which it emerges that the Abbasid army used big gun towers in the conquest of the city of Amorium in 213/837. These gun towers consisted of movable trebuchets (manānīq) on wheeled gun carriages (karāsī tahtahā ‘ağal)\(^2\) and were called dabbāba.\(^3\)

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In this connection it should be noted that a moveable battering ram is depicted in a relief which can be dated as far back as 880-865 BC from Nimrud near Nineveh.\(^4\)

The question of the various stages of development of this piece of war machinery in the Islamic world has not yet been examined. A fairly advanced form of battering ram, called *zahha†a*, is to be found in the *al-An†iq fi l-man†aq†iq\(^5\)* from the 8th/14th century. It was used for breaking open the gates and walls of fortresses. The battering ram consisted of a covered internal space which was almost always protected against projectiles and incendiary mixtures; inside the space there was an operating team which pushed an enormous iron ram in continuous rhythm against the gate or the wall until it broke down. The extant illustration makes it clear that the battering ram was completely armoured. It contained a foldable bridge which was fastened with hinges in the front at the bottom plate; like a bridge for crossing moats, this too could be let down by means of iron chains.

A great similarity with this type of battering ram can be seen in the two following illustrations from the manuscript in the Bayerische Staatsbibliothek, Munich, cod. germ. 734:\(^6\)

It is remarkable that Giovanni Fontana (1st half of the 15th c.) depicts a moveable battering ram at the beginning of his *Bellicorum instrumentorum liber*\.\(^7\)

He provides the following caption to the illustration: «War machinery which is called alphasat in Arabic.» I presume that the expression alphasat originated from a distortion of the Arabic term *az-zahha†a*.