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Mechanism of Firearms: Pre-colonial India

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Abstract: **The history of gunpowder and guns in India is quite ancient. However, it is not certain whether the use of firearms originated in India. But it cannot be denied that it was born in the East, not in the West. At the same time, there is no denying that the progress and proliferation of the guns were in the hands of the Europeans. Europe's industrial revolution and scientific revolution greatly influenced the history of technology throughout the world. The evolution of the gun could not ignore this effect. It is here that the evolution of the gun, especially the mechanism, has been attempted to explore through the lens of Indian history. This seems very important in Indian science-technology and military history.**

Keywords: **Firearms, gunpowder, saltpetre, Muzzle, barrel, Projectile.**

Mechanism of Firearms: Pre-colonial India

Science is a radical movement of change while the scientists have considered themselves as vanguard of the movement which has been contributing to human welfare and values. Further, it has also been assumed that with the progress of science and technology social progress would automatically follow.[1] Technology is different from in so far as it is, in sense, the property of a country which develops it. Technology has its connection with both contemporary and as well as the past technology. On the other hand, art is a coalescence of external objects and psychological state.[2] Making of Firearms was a combination of science, art and technology. The catastrophic calibre of firearms came to be derived from fireworks in celebrations, and in the quest for deriving the formula of gold by the alchemists. Historian Joseph Needham states that it was the pursuit of the elixir of immortality. The direct ancestor of the firearm is the fire lance. The prototype of the *fire lance* was invented in China during the 10th century and is the predecessor of all Firearms. The mention about its discovery vaguely varies. But whatever has been learnt in the due process is irreversible and cannot be unlearnt. Mankind has progressed much ahead since the discovery of gunpowder leading to one and many innovations in military science. Therefore, it will be interesting to study the mechanisms of firearms and its Evolution.

Emergence of Small Firearms:

Traditionally, bows were the most widely recognized weapon in war. A sizeable portion of the infantry was equipped with missile weapons.[3] Indeed, even well after the vogue of firearms, during the rule of Mughal Emperor Akbar, foot toxophilite dwarfed musketeers by around three to one. They were equipped either with an oversized version of the Central Asian composite bow— it was conceivable to draw a lot heavier bow while by walking than on horseback—or with an increasingly customary Indian weapon, the longbow. The last sort included both self bows, produced using a solitary bit of wood, and bows built from overlaid bamboo, like the Japanese *yumi*[4] Greek trespassers figured out how to fear a weapon that could send a yard-long shaft totally through a hoplite's shield and breastplate. As in England and Wales during the Middle Ages, the longbow became both a method for self-preservation and a method for entrance into the military service for ordinary people. The longbow has a long and distinguished history in India, going back to ancient occasions. It was used by saints out of legends like Lord Rama and Krishna, yet it was likewise an undeniable intimidation on the battlefield.

Other famous weapon for the mass, one that represented a particularly vexing issue for the elites of Central Asian and India as well as the mounted nobility of Europe, was the crossbow. According to Erik Hildinger, this weapon was not so popular among the Mongols. [5] It was inferior to the composite bow or longbow in some ways, especially its slower pace

of discharge, yet at the same time presented a unique challenge for nomadic horsemen attempting to pacify sedentary peoples.[6] It was easy to master and could be used by nearly everybody, even those who are not in peak physical condition. Physical and Mental health was minor in this concern. Unlike conventional bows, it could be used comfortably from a prone position or from behind cover and kept cocked while a marksman deliberately arranged a shot or trusted that an objective will develop into view. Crossbows were ideal for sniping and ambushes. While the longbow was an extremely powerful weapon, it constrained its clients to stand and fight in the open. The crossbow did not have this incapability, making it in many cases an extraordinary weapon for fighting on foot and fighting from the defensive. Another favourable position was that its shorter, heavier shot hit an objective with more prominent power than a standard bolt or arrow. As Babur's experience appears, even mounted archers found the crossbow useful on occasions when they were forced to fight on foot. Most Central Asian and Indian crossbows were essential models; positioned utilizing a stirrup or snare, yet there were additional instances of a kind alluded to as the charkha, or 'wheel' evidently a heavier model equipped with a windlass.

In Central Asia and India the crossbow was alluded to by the Persian expression *tufang*—a similar word used to depict the European harquebus/harquebus after its commencements. As the comparative classification proposes, the musket developed to fill a lot of a similar job. Prime parts of the musket like the stock and trigger mechanism, were acquired from the crossbow. Like the crossbow, it was easy to learn, easy to exercise and requisite even less physical strength to use effectively. It could be fired easily from cover and from a kneeling or inclined position. It could be kept positioned inconclusively for cautious pointed shots or aimed target. Undoubtedly, it was initially less accurate than a bow or crossbow round shots were less efficiently effective than arrows. But the musket did offer unique advantages. A matchlock harquebus was precisely a lot less complex than a crossbow and less expensive to manufacture. It had roughly a similar pace of shoot about 2-3 shots per minute and effective range about 100 yards as a crossbow but had much superior penetrating and stopping power than a crossbow or even a longbow. This was especially true at close range, where a musket ball moved at a much higher velocity than an arrow or crossbow bolt and transferred much more energy to the object. Delicate lead projectiles sprouted after effect, making significantly more tissue harm and bigger injury channels than those made by bolts particularly the bolts with narrow, armour-piercing points that were regularly applied in battle. This trademark musket was prevalent for chasing, particularly in quest for perilous game. Matchlock-balls or projectiles were substantially more penetrating for entering protective layer of armour and significantly more liable to cause wounds that were quickly weakening or lead to lethality. While skilled firearm's ball were slaughterhouse enough, there were additionally records of the Mughals utilizing ammo that was uncommonly intended to pierce shield and hurt like a sword. The system used to succeed this is hazy—it may have been a guided shot comparative toward a shot made of iron or some harder compound that would infiltrate further without losing its shape. Firearms were especially compelling against mounted force or artillery—a hit to the focal point of mass could leave horsemen in a split second. Projectiles even caused awful harm on war elephants. The introduction of the musket was one of the essential reasons why elephantry lost their primary job on Indian battlefield during the pick era of the Mughal Empire.[7]

The Indian musket had similar origins but evolved uniquely in contrast to its European counterpart. The crude brass muskets used by Babur's men were replaced by more refined weapons manufactured from iron or steel. They were designed for accuracy, not a high rate of fire. After some time various highlights were included for this reason, including thicker and longer barrels, iron sights, bipods, recoil pads and slings—which were used for steadying aim as well as ease of carrying. At the beginning of the colonial rule, British observers noted that Indian style muskets—little changed from the Mughals or more specifically Akbar's day— were often much more accurate than 'modern European models'. Weapons of this sort not just made it a lot simpler for a conventional client to accomplish fundamental capability when contrasted with arrow based weaponry's precarious expectation to learn and adapt yet they were likewise incredibly deadly in the hands of a really gifted expert. Mughal muskets were very enormous, firing balls weighing up to 2 ounces or 875 grains. The huge bores propose a weapon intended to be utilized cautiously, from an inclined position or from behind cover. There were also even bigger wall-guns, with barrels as long as six feet that launched projectiles as heavy as 3.5 ounces or 1500 grains. These clearly required some sort of protected stand to utilize securely. Muskets optimized for efficiency may have significantly narrowed or even reduced the bow's conventional superiority in accuracy over regular smoothbore firearms. While basic optimal design guarantees that a bolt is a more precise shot than a round musket-ball, under certain conditions the ability to use a rest and more carefully aim, the addition of a sighting mechanism a musket may turn into an increasingly exact weapon framework in exclusive impact. The difference in rate of fire remained, with an archer capable of firing about three times as fast as a musketeer, however that deficiency may not generally have been

so overpowering in a setting where the normal trooper just conveyed two or three dozen rounds of ammo and would be compelled to find a steady speed throughout a fight. Physical stamina was also an issue in the case of a composite or long bow, especially heavier weapons with draw weights approaching or exceeding 100 pounds. Archers would not be able to keep up a six shot per minute or higher pace for very long without resting. The bow's capacity to fire quickly in short blasts was really an advantage for Mughal musketeers, who were normally bolstered by foot- toxophilite. The archers' high volume of fire covered the more deliberate work of the muskets. In this framework musket and bow were not contending weapons yet correlative ones.[8]

Contemporary descriptions of the weapons used by Akbar and his elite guard indicate the Mughals' comprehension of the musket as a precision instrument. Experts painstakingly investigated and test terminated new muskets and compiled a wide range of statistics to track them—the weight, the place and date of assembling and the names of the gunsmiths. Each musket likewise assigned a serial number. This data was recorded as well as was demonstrated by markings engraved on the completed pieces. Obviously this level of care and attention to detail probably did not extend to all of the weapons used by regular troops, but accounts of the musket's actual use in battle emphasize the importance of accuracy and marksmanship. Akbar, aside from his own reputed exploits as marksman, maintained a special group of crack shots. Snipers assumed a significant job, particularly in attacks and prolonged standoffs. Not the entirety of the best marksmen was in the positions of the Empire. On the various occasions Mughal commanders were driven to distraction by the harassment of enemy snipers. Babur pardoned and took into service an especially skilled and dangerous enemy crossbowman after witnessing his exploits during a siege. An accomplished musketeer who did similar damage to Humayun's forces was not so lucky. That Emperor had him put to death. Akbar was infuriated by the punishment inflicted by an elite regiment of Rajput musketeers during the siege of Chittor and was frustrated when those "evil-doers" managed to slip away after the city's fall. Despite the harm they caused, Abu al-Fazl later expressed grudging admiration of the 'skilful' enemy and the clever trickery they used to escape. Descriptions of musketeers, both friends and foes, often emphasized their skill and expertise. In Akbar's military, there was an arrangement of 15 positions to characterize musketeers by pay evaluation and capacity. The musket was not just a rough actualize—it was a considerable weapon in the hands of achieved proficient officers.

Akbar stood unrivalled in manufacture of matchlocks and as marksman.

a) These were now made so strong that they did not burst.

b) To avoid accidents which formerly occurred in making matchlocks joining pieces of iron flattened by the hammer and the anvil, Akbar devise an 'excellent method of construction'- by flattening iron and twisting round obliquely in form of a roll and then joining the folds.

c) Three or four cylindrical pieces of iron pierced when hot with an iron pin were joined to make a gun or two.

d) Guns were made of the length of two yards which smaller on *damanak* were 1 ¼ yd long.

e) There was some change in the manufacture of gunstock.

f) Guns were made so as to fire them without a match by moving cock.

g) In the process of manufacture a barrel double was inspected service times by Akbar as described in detail by Abul Fazl.

h) The manner of cleansing guns is also said to have improved under Akbar, who invented a wheel by moving which 16 barrel could be cleansed in a short time

Gunpowder:

The gunpowder industry achieved a progressive change in the Indian situation during the medieval period. The Persian and Sanskrit wellsprings of medieval period edify us about the ingredients such as saltpetre, sulphur and charcoal used for making of gunpowder and furthermore talks about its different plans and application for military reason and making firecrackers. These sources are also a rich store house for providing information on preparation of acids, both organic and mineral acids, alkalis, preparation of ink and poisons and several chemical components used for making them. The essential elements of black powder or gunpowder are saltpetre, sulphur and charcoal. All of these components were easily available in the Indian subcontinent.[9] There is a rich amount of data in both Sanskrit and Persian texts of this period on

this concern. We shall be dealing with all the three components separately with an extraordinary accentuation on their reference in the Sanskrit and Persian sources.

Saltpetre: Saltpetre, the primary fundamental part, was effectively accessible through lixiviation and crystallization in Gangetic India.[10] It was also acquired from soil blooming in Bengal during the monsoon.[11] Basically, the Sanskrit sources provide information about saltpetre as one of the components in the transmutation of metals. *Rasarnava* mentions the use of saltpetre or *Sauvarchala* in the transmutation process. The text explains the use of saltpetre with other substances to make a *vida* (mixture) to kill all metals.[12] Later in the content, there is a reference to the slaughtering of gold with the help of saltpetre alongside different parts.[13]

Rasahridaya by Govinda Bhagavat and Rasa Ratna Samuccaya by Vagbhata allude to Sauvarachala or saltpetre in the classification of six salts.[14] It is in Katukacinatamani by Gajapati Prataparudradeva that we discover the utilization of saltpetre as a component in gunpowder mixture. The term used for saltpetre in *Yavakshara*. It likewise makes reference to Panchakshara or five sorts of salt.[15] Verses 201-202 of *Sukraniti*, a sixteenth century treatise by Sukracharya, mention the use of Saltpeter in the formation of fire- powder.[16]Further, in the same text, verse 203 and verses 206-08 provides the recipes for the use of gunpowder in pyrotechnics and Firearms respectively.[17]

In the Persian sources too there is a lot of data on saltpetre yet it is dispersed. Adat ul- fuzala, composed by Qazi Khan Badr Muhammad Dharwal at Jaunpur during 1419-20 A.D and *Sharaf-nama-i Ahmad Munairi accumulated by Ibrahim-I Qawam Faruqi during 1457- 64 AD, clarify shora or saltpeter in various manners*. Abul Fazl's well-known work Ain-i Akbari gives intriguing data about Saltpeter and its employments. There is a reference to the utilization of saltpetre as a coolant.[18] Fundamentally the enough use of saltpetre as the base element for gunpowder and the terminus utilization in wars and ceremonial fireworks. The text also additionally specifies the *subah* of Berar as the region from where saltpetre was grasped. *Bayaz-I Khushbui*, a mysterious book of Shahjahan's rule [1605-27AD] contains clear insights concerning the utilization of *shora* in gunpowder. Particularly, its thirteenth *chapter* is exclusively devoted to atishbazi (fireworks or pyrotechnics), wherein various recipes and the quantity of shora along with different ingredients are mentioned.[19]

The contemporary foreign travelogue also shed some light on the procurement of saltpetre. Francisco Pelsaert, a Dutch traveller visited in India from 1620 to 1627, provides information on the procurement of Saltpetre[20]. The author states that Saltpetre was found naturally near Agra and its outskirts in the periphery. The method of its extraction has been explained in detail. Further, the author gives the quantity of Saltpetre produced in Agra as a probable 5,000 to 6,000 *maunds* for each annum.

Sulphur: Sulphur is the second fundamental element of gunpowder. The Sanskrit sources have fascinating data on the origin of Sulphur. The texts like *Rasarnava, Rasarnavakalpa. Rasahrdayatantram, Rasa Ratna Samuccaya, Katukacintamani* and *Sukraniti* give point by point record of its 'source' [These writings follow a fanciful starting point of Sulphur, which is more likely to mythoscientific], varieties. Characteristics, refinement and methodology of its uses also clearly mentioned. Out of the above mentioned sources especially *Rasa Ratna Samuccaya provides* a comprehensive account of Sulphur and its uses. It gives a mythological origin of Sulphur by claiming that it originated from the *menstrual* discharge of goddess Parvati at *Sveta dvipa* and came out of the churning of milk ocean *Ksira Sagara* as *gandhak* along with nectar.[21] Damodar Joshi deciphers goddess Parvati as nature and *Sveta- Dvipa* as Sicily, stirring of the sea as volcanic emissions and menstrual release as the liquid materials from the fountain of liquid magma.[22] The text mentions four varieties of Sulphur based on colour viz., white, yellow, red and black. Verses 12-15 of the third chapter in the text provide this information and are being quoted below:

Based on shading it [Sulphur] is of four kinds, I. e., white, yellow, red and dark. The white assortment is called khatika which is useful for lepana (gluing) and loha marana (changing over metals to remains). That which is yellow in shading is called amala sara. The equivalent is called Sukapiccha too. It is considered best for rasakarma and rasayana karma, both. The sulphur is called sukatunda and is useful for dhatuvada vidhi (catalytic forms/purposes). The dark assortment of sulphur is uncommon. On the off chance that accessible it can devastate infirmity/maturing process and may cause passing.[23]

According to the author Sulphur possessed a superior *rasayana* (rejuvenating) property and was known to have a sweet taste. The text mentions two types of impurities.

- The insoluble impurities from the first type

- The soluble impurities form the second one.

For purification the *Rasa Ratna Samuccaya* advises to melt sulphur with cow's ghee and pour it in milk or other extractives through a cloth. When repeated several times this process yielded pure sulphur. Purified sulphur was to be used both externally and internally for the treatment of skin disorders. It could stimulate digestive system, remove toxins and improve vigour and strength. It could also impart potency to mercury and alleviate its toxicity. Curing of skin diseases, improvement in digestion, removal of toxins, the removal of bacteria and worms, are some of the other uses of Sulphur mentioned in the text. For internal use purified sulphur or its oil form or *druti* had to be used. *Rasarnava* too mentions that any metal could be easily killed by sulphur.[24] Verses 336-337 of *Rasarnavakalpa* recommend the use of sulphur according to the prescribed rules as its otherwise nectar like qualities can change into poison.[25]

The Persian sources like *Ain-i Akbari* and *Bayaz-i Khushbu* give information about the procurement and uses of sulphur. While the earlier source sheds light on its uses in metallurgy and the latter highlights its importance in pyrotechnics. *Ain-i Akbari* mentions that mines of Sulphur are found in *Bengal.*[26]*Bayaz-i Khushbu* mentions the use of *gugird* or sulphur in the preparation of fireworks.[27]

Charcoal: The third basic ingredient of gunpowder is Charcoal. India being immensely rich in flora, charcoal was produced from different varieties of trees each having its distinct quality. Few texts name the plants whose charcoal was used in the preparation of gunpowder.

○ *Rasa Ratna Samuccaya* informs us about charcoal or *kokilas***.** The verse 18 of the seventh chapter gives three synonyms of charcoal viz. *Sikhitra*, *pavakocchista* and *angara.* It defines the *kokilas* as the burning charcoals extinguished by itself without water.[28]

○ *Katukacintamani* of Gajapati Prataparudradeva [King of Orissa] written in the early sixteenth century mentions two types of charcoal for pyrotechnicmixtures. **The first** type of charcoal is called Angar [29] or the charcoal made of bamboo, pine, willow, etc.**The second** type is *Arkangaar* or the charcoal prepared from the wood of the *Arka*.[30]

○ It is from the verses 201-202 of *Sukraniti* written by Sukracharya in the sixteenth century that we come to know about the use of the plants *Arka (Calotropis gigantea)* and *Snuhi (Euphorbia nerrifolia*) for the preparation of charcoal.[31] Thirteenth *bab* of the *Bayaz-i Khushbui* mentions the use of *zughal* (a live coal) as different from *angisht* (charcoal) an ingredient in a gunpowder recipe.

Gunpowder Recipes:

Most of the sources of this period provide various recipes for the preparation of a gunpowder mixture. *Rasopanisad* narrates the preparation of *Sphotaka* or explosive mixture. The author mentions the heating of various salts[32] with alkalise and the addition of wax and sulphur to form an explosive mixture.[33] The *Katukacintamani* of Gajapati Prataparudradeva has a section on the manufacture of specific fireworks which was discovered by firearm historian

P.K. Gode. He asserts that the text contains formulas for the preparation of fireworks like *Kalpavrakshabana, Chamarabana, Chandrajyoti, Champabana, Pushpavarti, Chhuchhundrirasabana, Tikshananala* and *Pushpabana.*

P.K. Gode mentions the use of the following materials in the manufacture of fireworks in the text:

Sulphur *(gandhaka),* Saltpetre *(yavakshara),* Charcoal *(angara),* Steel and Iron powder *(tikshna loha churna* and *loha churna),* copper carbonate *(jangala),* yellow orpiment *(talakam* or *harital),* ochre *(garika),* wood of 'khadire' tree *(khadiram daru),* hollow bamboo piece *(nalaka),* wick *(bartika),* five salts (*pancha kshara),* lodestone *(akhupashan),* pulp of castor seeds *(aranda majja),* mercury *(sutam),* rice paste *(annapista),* tin or lead *(naga),* charcoal from the 'arka' wood *(arkangara),* cow's urine *(gomutra)* and *cinnabar* (vermilion).[34]

Sukracharya's *Sukraniti* gives enough indication about the presence of the knowledge of manufacturing gun-powder by providing recipes of the same. The verses 201-202 of the text describe the method by which it was produced. The author advises to powder and mix five *palas* or *four tolas* of saltpeter, one *pala* of sulphur and one *pala* of charcoal. This kind of charcoal was prepared from the wood of *Calotropis gigantean* [Crown flower] and *Euphorbia neriifolia* [Indian Spurge Tree] by destructive distillation. Thereafter, the mixture needed to be mashed in the juice of various plants and garlic, dried in the sun and grinded to obtain the fineness of sugar. This resulted in the production of fire-powder. Further, the verse 203 suggests adding six or four *palas* of saltpetre instead of five *palas* to produce fire-powder for a gun with the

proportion of other substances remaining the same.[35] *Bayaz-i-Khushbui* discusses in detail the method of preparing cannon balls for *tufung* and *top***.** It also provides eighty seven gun-powder recipes for use in pyrotechnics. The exact measurements and quantities of various ingredients to be used are vividly explained in the text. Most of the recipes mention the use of four basic ingredients in various proportions. They are *shora* (saltpeter), *gugird* (sulphur), *zughal* (live coal) and *faulad* (powder of iron/steel). The quantities of these ingredients differ to give varied results in terms of the sound and smoke created after the explosion. While the quantity of *shora* remains more or less the same at 10 12 *misqal***,** the other ingredients vary. A *misqal* was equivalent to 4.23 grams.[36]

Some important recipes are *Ayar-i-Tarakak, Ayar-i Gule Sadbarg* and *Ayar-i Tutak Andarkafas.* Unlike other recipes each of these three recipes is followed by directions to bring desired results by change in the proportion of the ingredients. To prepare the recipe of *Ayar- i Tarakak,* the text advises to use two dirham of *gugird* (sulphur), one dirham of *shora* (saltpetre) and two dirham of *angisht* (charcoal). The note states that the loudness of the result depends upon the quantity of paper in the mixture. According to *Bayaz-i-Khushbui* its range is same as of *Ayar-i Hawal.* The recipe of *Ayar-i Gule Sadbarg* includes ten darams of *shora***,** ten darams of *gugird* and seven *dirham* of angist. The text also gives a detailed method to prepare thismixture. The text advises to increase the quantity of anyone of the ingredients in order to produce more smoke. In case less smoke is desired the quantity of anyone of the ingredients may be decreased. The preparation of *Ayar-i-Tutak Andarkafas* needs ten *dirham* of *shora***,** 13½ *dirham* of angisht, six dirham of *gugird*, twelve *dirham* of *faulad*, three *dirham* of *nakhudgugird***.** All the ingredients are to be mixed in vinegar and dried in the sun. This process is to be repeated ten times and the mixture is to be covered and stored in a container. *Gugird* is to be mixed fifty times and grinded. It should be grinded five hundred times. The container or *kafas* is to be coiled with an iron wire and two pieces of wood are to be placedon its top to form a wheel. On ignition the wooden pieces soar in the air and the firework display is witnessed. This recipe is also called *Ustad-i-Awaz Baghdadi*.

Application of Gunpowder:

The Sanskrit and Persian sources of the period enumerate the varied applications of gunpowder. Broadly, these can be classified into two types:

(a) Military applications: The use of gunpowder as weapon of warfare was an important phenomenon in military operation during medieval time. There were many firearms were used but three weapons like ban, cannon and guns were most popular.

(b) Pyrotechnics: The *bana* (rocket) was predominant among the fireworks produced in medieval India. P.K. Gode traces the earliest reference of *bana* or rockets to *Katukachintamani* .The text mentions eight important types of fireworks and most of them were *banas. Kautuka- Cintamani* provides formulae for the preparation of *banas. Akasabhairava-Kalpa* spells out three *banas viz.Bana-vrksa, Camaraka* and *Bana.* One meaning assigned to *Bana-vrksa* is the hanging rockets discharged from trees while the other meaning suggests of the rocket producing tree-like formations with different heights.[37]

Bayaz-i Khusbui refers to numerous fireworks that were in used seventeenth century. The Chapter on *Atishbaazi* in the text gives the following fireworks *Ayar-i-gul, Ayar-i-gul-i Nui- digar, Ayar-i-Tez Amal, Ayari- Gule Mahtab, Ayar-i Gule digar, Ayar-i Gule Nargis, Ayar-i- Aftab* etc. Thus, it seems pretty clear from the foregoing discussion that the early use of *bana* was limited to pyrotechny. The Persian source *Tarikh-i-Firoz Shahi* of Afif also mentions the use of *hawai* or rocket in fireworks meant for the celebration of the *Shab-i Barat* festivities at Delhi at the behest of the Sultan Firoz Tughluq. Afif calls the firework as *Hawaiha-i gulrez anbarbez mi bakht* or 'flower scattering rockets' which seems an improvisation in pyrotechnics.[38] *Maasir-i Mahmud Shahi* is a chronicle of the Khalji kingdom of Malwa which describes the display of fireworks at Mandu. I.A. Khan considers that the above mentioned display was not of *naphtha* but pyrotechnic propelled by gunpowder.[39] According to Mira Roy *Akasabhairava-Kalpa* mentions the use of *Syandanakrti-daruyantravisesan* as afirework in the form of a wheel ignited by *daru* or gunpowder. *Gode tried to prove by the reference Katukachintamani*, the presence of various pyrotechnics that included fireworks other than *bana.*

Trigger Mechanism:

The locks of military firearms are of particular value from a history of technology perspective as they are one of the few precision mechanisms made in volume that are readily dated.[40] It is of interesting, therefore, to examine such locks from an engineering perspective. Modern firearms take many different forms, but they all have the following components: A

'stock' or pistol grip, a 'barrel', and the 'action' which refers to the operating components of a weapon. One of the main parts of a stock (and, in some guns, the only part) is the 'butt-stock'. This is the portion of a long gun such as a rifle or shotgun, which is braced against the shoulder when firing. In the case of handguns, the pistol grip is used to secure the weapon when firing.

- Matchlock
- Flintlock

Matchlock:

The **matchlock** was the first mechanism invented to facilitate the firing of a hand- held firearm. Before this, firearms (like the hand cannon) had to be fired by applying a lit match (or equivalent) to the priming powder in the flash pan by hand; this had to be done carefully, taking most of the soldier's concentration at the moment of firing, or in some cases required a second soldier to fire the weapon while the first held the weapon steady. Adding a matchlock made the firing action simple and reliable by a single soldier, allowing them to keep both hands steadying the gun and eyes on the target while firing.

The matchlock was the first firearm with a trigger. The matchlock harquebus began to be used by the Janissary corps of the Ottoman army in the first half of the 15th century[41] by the 1440s. The idea of a serpentine later appeared in an Austrian manuscript dated to the mid- 15th century. The first dated illustration of a matchlock mechanism dates to 1475, and by the 16th century they were universally used. During this time the latest tactic in using the matchlock was to line up and send off a volley of musket balls at the enemy. This volley would be much more effective than single soldiers trying to hit individual targets.

Robert Elgood theorizes the Italian army used the harquebus in the 15th century, but this may be a type of hand cannon, not matchlocks with trigger mechanism. He agreed that the matchlock first appeared in Western Europe during the 1470s in Germany.[42] Improved versions of the Ottoman harquebus were transported to India by Babur in 1526.

The matchlock was claimed to have been introduced to China by the Portuguese. The Chinese obtained the matchlock harquebus technology from the Portuguese in the 16th century and matchlock firearms were used by the Chinese into the 19th century. The Chinese used the term 'bird-gun' to refer to muskets and Turkish muskets may have reached China before Portuguese ones. In Japan, the first documented introduction of the matchlock, which became known as the '*tanegashima*', was through the Portuguese in 1543. The '*tanegashima'* seems to have been based on *snap matchlocks* that were produced in the armoury of Goa in Portuguese India, which was captured by the Portuguese in 1510. While the Japanese were technically able to produce tempered steel (e.g. sword blades), they preferred to use work-hardened brass springs in their matchlocks. The name *tanegashima* came from the island where a Chinese junk with Portuguese adventurers on board was driven to anchor by a storm. The lord of the Japanese island '*tanegashima' 'Tokitaka'* (1528–1579) purchased two matchlock rifles from the Portuguese and put a sword-smith to work copying the matchlock barrel and firing mechanism. Within a few years, the use of the '*tanegashima'* in battle forever changed the way war was fought in Japan.

Despite the appearance of more advanced ignition systems, such as that of the wheel- lock and the snaphaunce (an early flintlock mechanism for igniting a charge of gunpowder in a gun), the low cost of production, simplicity, and high availability of the matchlock kept it in use in European armies until about 1720. It was eventually completely replaced by the flintlock as the foot soldier's main armament. In Japan, matchlocks continued to see military use up to the mid-19th century. In China, matchlock guns were still being used by imperial army soldiers in the middle decades of the 19th century.

Matchlocks were apparently, already being used in the whole of South Asia during the sixties of the 16th century were much inferior to the muskets used by the Portuguese on the Western coast of India. This is highlighted by the contemporary Portuguese accounts of an attack in

A.D. 1571 by the Sultan of Gujarat on Chaul then controlled by the Portuguese. According to an estimate based on archaeological and historical evidence, at this time, the superior

Portuguese muskets fired "one ounce shot over 400 meters while Indian infantrymen could send a half ounce shot for about half that distance".[43] Such a great difference in the performance of the Indian and Portuguese matchlocks might suggest that the this technology brought to South Asia [Specifically India] from Europe from contact with the Mamluks or noitals and the Ottomans was stagnating even at this early stage while it was continuously developing and improving in Europe.[44]

The Indian matchlock musket is often called *toradar during the pre-modern times*. The term *torador* is very popular. According to popular belief, firearms were introduced into north India at large by the founder of the Mughal Empire, Babur in 1526. He used them in great quantities during his invasion of the Indian subcontinent from Central Asia. One of his two master gunsmiths was nicknamed Rumi or 'The Ottoman' proposing that is the place the innovation at first came from.[45] Over time, Indian muskets further developed into their own characteristic styles, with progressively Persian impact. Mughal muskets are typically made of very good steel, empowering the utilization of higher charges of explosive. Their long barrels make for improved muzzle velocity, firing more accurately at longer ranges, provided the inside of the barrel is kept sufficiently clean as to minimize friction.

The matchlocks, country made guns has wooden butt and long barrel attached to the stock by numerous broad bands of brass is really interesting.[46] Matchlocks were very commonly used in medieval period in different areas of India. Matchlocks are now made so strong that they do not burst, through let off when filled to the top. Formerly to more than a quarter could not fill them by them. Besides, fattening pieces of iron, and joining the flattened edges of both sides made them with the hammer and the anvil. Some left them, from foresight, on one edge open; but numerous accidents were the result, especially in the former kind. An excellent method of construction has invented under the patronage of medieval Indian ruler. The gunsmith flatten iron, and twist it round obliquely in form of a roll, so that the folds get longer at every twist, they then join die folds; not edge to edge, but so as to allow them to lie one over the other, and heat them gradually in the fire. Cylindrical pieces of iron were also taken by them, and pierce them when not with an iron pin. Three or four of such pieces make one gun or in the case of smaller ones, two guns. Guns were made two yards length; those of a smaller kind are one & a quarter yards long, and go by the name of Damanak. From the practical knowledge of their Majesty, slight movements of the cock guns are now made in such a manner that can be fired off, without a match. Bullets are also made so as to cut like a sword. There are now many masters to be found among gun makers. e.g., Ustad Kabir and Husain. Iron, when heated, loses about one-half of its volume. When a barrel is completed length ways, before the transverse bottom piece is fixed to it, they engrave on it the quantity of its iron and the length both being expressed in numerals. A barrel thus for finished, is called dual. They further learn that the quantity of gold and lapis lazuli used makes much difference to the gun. Again, when ten of such guns are ready, Akbar adders to in lay the mouth of the barrel and the butt end with gold.[47] In the Ain-i-Akabari mentioned the price of an ordinary matchlock was lay between *half rupee* to 1 mohur.[48]

The matchlock long barrel was usually attached with the stock by leather strips and strengthened with side plates of steel.[49]In the illustration found the kind of Matchlock has a form identical to those of the earliest handguns developed in Europe in the middle of the fifteenth century. The manufacture of matchlocks, guns & cannons was encouraged by Akber.[50] Abul Fazl mentions that with the exception of Turkey, probably no other country was equal to the Mughals in this field. The barrels of Akbar's matchlocks were of two lengths, 66 inches and 41 inches. They were made of rolled strips of steel with the two edges welded together.[51]

Flint Lock:

The flintlock is the most venerable of the lock technologies. The flintlock mechanism, like the pendulum clock mechanism, is amazing from an innovation standpoint. This single device solved so many of the problems of the time, and it did so using the fairly primitive tools and technology already available then. The flintlock was quite an accomplishment. The basic goal of the flintlock is simple: to create a spark that can light the gunpowder stored in the barrel of the gun. To create this spark, the flintlock uses the 'flint and steel' approach. The idea behind flint and steel is straightforward. Flint is an amazingly hard form of rock. If you strike iron or steel with flint, the flint flakes off tiny particles of iron. The force of the blow and the friction it creates actually ignites the iron, and it burns rapidly to form Fe_3O_4. The sparks that we can see are the hot specks of iron burning. If these sparks come near gunpowder, they will ignite it. The efficiency of the flintlock mechanism is accompanied by a similar improvement in the loading of a musket.

In the early years of hand-guns the soldier carries a powder flask, from which he tips a small charge of gunpowder into the pan of the gun and then a larger quantity down the barrel following it with a round metal ball and sufficient wadding to hold it in place, before ramming the whole charge tight with his ramrod.

Historically, writers made no distinction between this term and snaphaunce, the former being first recorded in 1683. The earliest flintlocks were developed from snaphaunces in the first quarter of the 17th century.[52] The flintlock reigned supreme as a system throughout the 18th century and flintlock muskets, also referred to as 'firelocks', were the infantry's principal weapons in most European nations and in Indian Sub-continent. The flintlock ignition system, despite the inevitable delay between the pulling of the trigger and the firing of the musket, proved far more effective militarily than the matchlock and was much less expensive and complicated than the wheel lock. Matched with a rifled barrel and carefully handled, it produced a military weapon of great reliability and power. Until the early 19th century, flintlock-ignited weapons systems, ranging from tiny pocket pistols to heavy naval cannon, were adopted for both civilian and military use and it was with the flintlock system that experiments were made most extensively with the earliest breech-loaders.

The flintlock therefore needs:

- A piece of flint or chakmaqi
- A piece of steel
- A place for the sparks to touch gunpowder

The flint needs to move at high speed and strike the steel in such a way that the sparks fall into some gunpowder.

The main parts of a flintlock are generally:

- The hammer, which holds and accelerates a piece of flint
- The mainspring, which powers the hammer
- The frizzen, which is the piece of steel the flint strikes
- The pan, which is the place where a small quantity of gunpowder waits to receive the sparks

One of the earliest kinds of guns that used a piece of flint, not a lighted match as used a matchlock gun, for igniting the gun-powder and shooting the bullet this is an outstanding example of a flintlock gun. Flint, the stone that sparks when struck and hence called in colloquial idiom 'chakmaq', being its main component, the gun is also called *chakmaqi banduq* or *bandook patharkala*, that is, the gun that used 'chakmaq' or flint stone as its main component. It was the kind of gun that consisted of a self igniting mechanism. The gun contained a hammer, which, when struck on a piece of flint, sparked, igniting the gun powder in the pan resulting in the bullet's discharge. In India, it was first introduced during the early years of Jahangir's reign [1605-27] and even his Impress Nurjahan Begum used it and gave a sitting to a portraitist. It was introduce in India by the British and the French. It was also known as 'Brown-Bess' and was the major infantry weapon until it was replaced percussion cap system about the middle of the 19th century. Carbine was a short barrelled flint-lock with the muzzle slightly trumpet shaped, it was also famous as 'blunderbuss.'

Obviously a royal treasure, this single-barrelled, muzzle-loading flintlock gun has a long, fine barrel damascened in gold and silver with engraved letters on it. The curved butt rendered it easy to hold it under the armpit. It could also be fired from a tripod or by being kept on someone else's shoulders. Flintlocks/firelocks were present in the Mughal Empire during the second half of the seventeenth century.[53] Irfan Habib in Dev Raj Channa Lecture, (1970) points out, Pietro Della Valle's account suggests that a handgun fitted "with a flintlock after the English fashion" was an object of curiosity for Zamorin of Calicut in A.D. 1623. According to him, a flintlock was "a thing unknown to them [i.e. people at Calicut], for their gun have only matches".[54]

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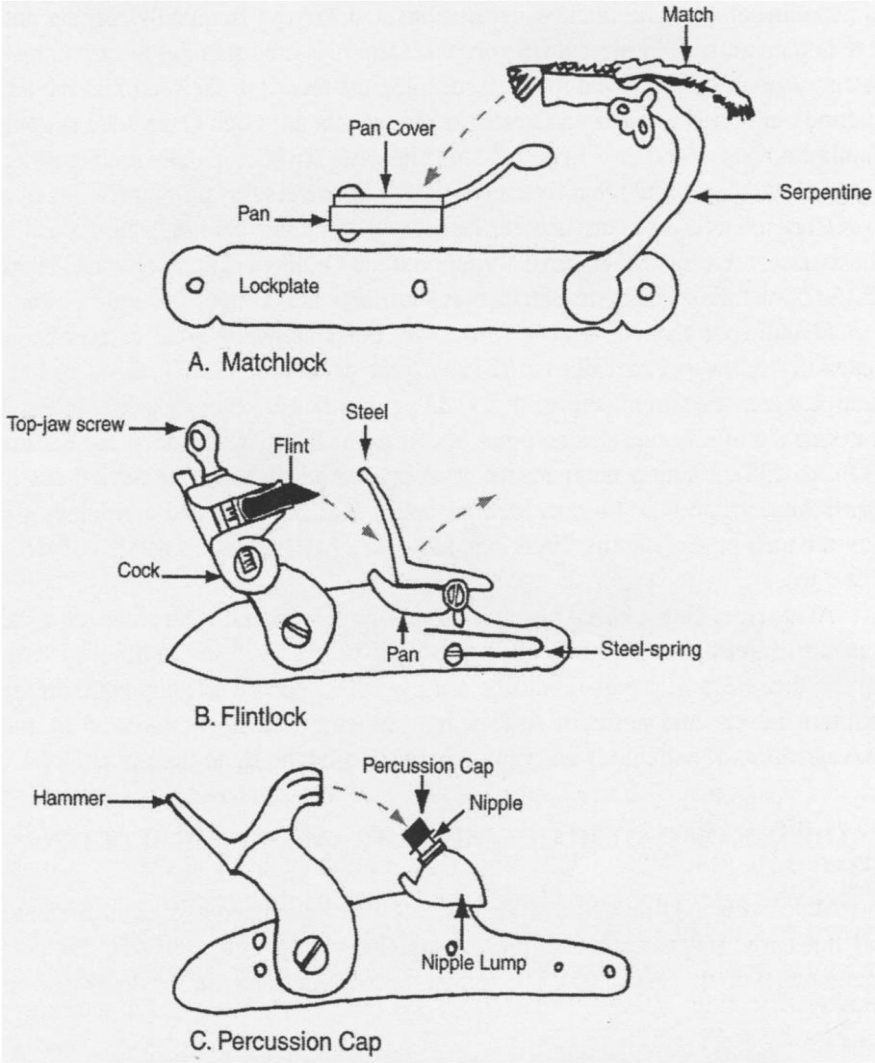

The types of ignition systems used on muzzle loading musket [Matchlocks, Flintlocks, and Saltpetre: The Chronological Implications for the Use of Matchlock Muskets among Ottoman-Period Bedouin in the Southern Levant

Author(s): Benjamin Adam Saidel

Source: International Journal of Historical Archaeology, Vol. 4, No. 3 (September 2000), pp.191-216

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Barrel: The cylindrical tube designed to contain the pressure of a propellant and direct the projectile. For many weapons it consists of chamber and bore which may be rifled or smooth bore. Indian Guns barrels vary in length but are generally much longer than European ones. They were in polygonal shape or round section or combination of both with large powder- chamber and thickened muzzles decoratively shaped. As in Turkish and some Persian barrels, the muzzles terminate in monsters or tiger heads or fluted capitals. Flower like Lotus shaped cannon muzzle also can be seen.

During the forging barrels were tested or endurance; they partially or wholly filled with gunpowder and fired; accuracy of fire was tested at the same time. If the test was successful, the decoration of the barrel, the form of the stock, lock and the ramrod were decided upon and Gunsmith' marks and dates were stamped. Barrels were damascened in gold and silver with floral arabesque. Bands of foliated scroll ornament, inscriptions, also animal and figure motif in low relief, antelopes, tigers, birds, figures of hunter and nautch- girls , as well as Gods from the Indian mythology also depicted. [55]

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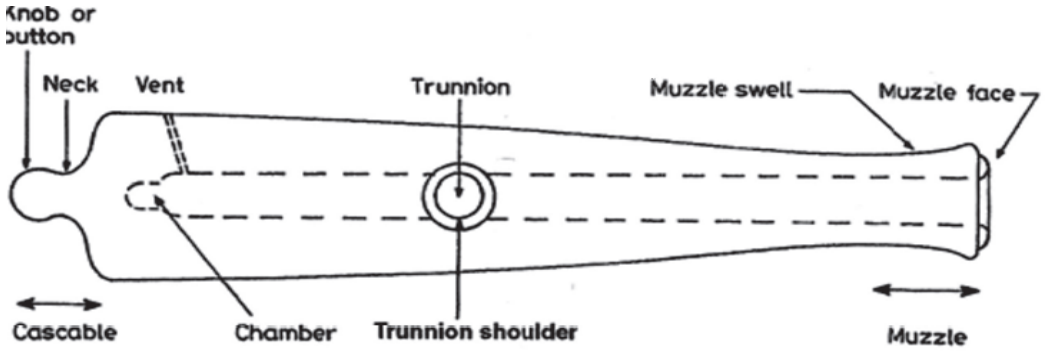
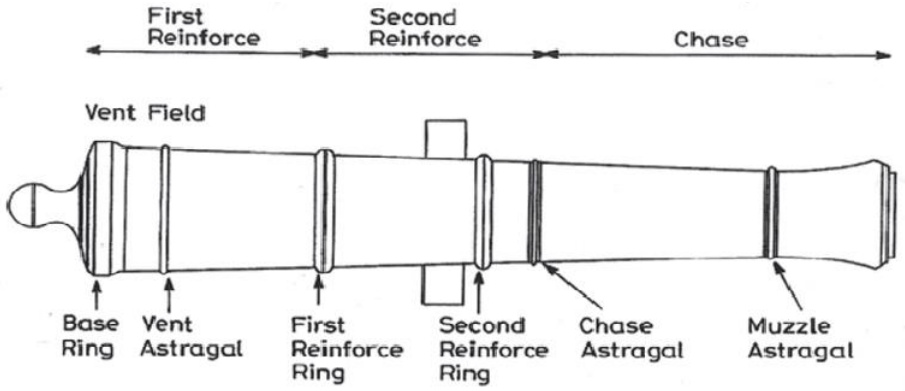
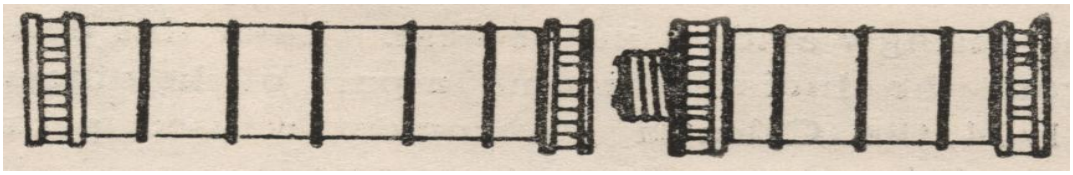
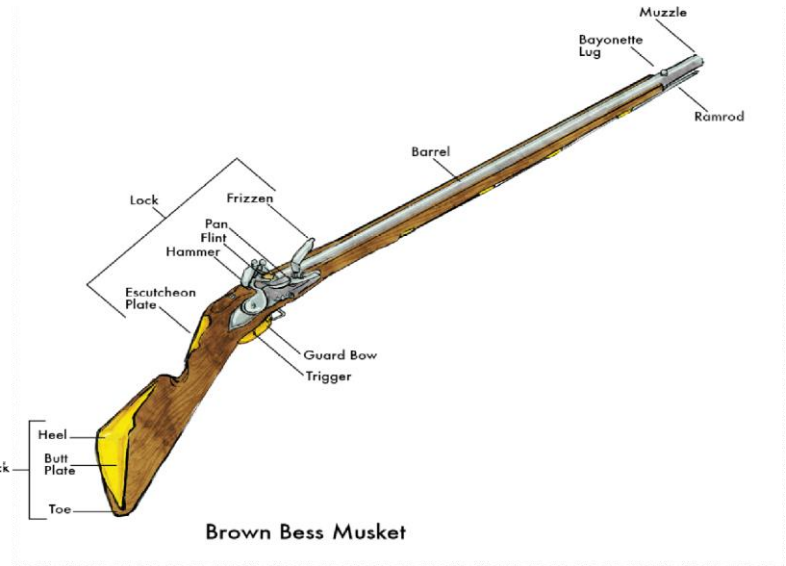


[This image is taken from PK Chattopadhyay, Cannon of Eastern India]



[Schematic diagram showing the various parts of typical cannon, PK Chattopadhyay, **Documentation of Cannons of Eastern India,** *Indian Journal of History of Science*, 47.1 (2012) 157-168]





[Source: internet]

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Firearms Moulding:

There are two methods of making moulds as described by scholars. One of the methods is described by R. Balasubramanian in his book 'The *Saga of Indian Cannons'.* According to this method, mould was made as a complete whole. For the preparation of this kind of moulds, the tapering circular wooden beam of the same size was taken. An extension was made to the muzzle so that the molten metal could easily pour into the mould. Then after greasing the wooden beam the rope was round over it, for making the margin of one inch to form the barrel. Then the actual shape was made by coating layer of clay one after other. When the one layer of coat was dried then the other layer was applied. After the model took actual shape of the cannon the truninons shaped wooden block and the decorative pattern were attached to it, then the cover of molten wax was applied to it. The model was made larger in dimensions, in order to allow the contraction for cooling.[56] On this model, the mould was prepared, by applying the semi liquid mixture of clay, and sand. This mixture was made carefully, so that it could flow on the pattern minutely. The layers of mixture were applied one after other, in a manner, when one layer dried the other was applied. After reaching to the thickness required the mould was ribbed, when the mould was completely dry. Then the trunnions [a supporting cylindrical projection on each side of a cannon or mortar] and the wooden beam were removed, after that the rope was un-winded. Then the mould was kept on fire to melt the wax, which make easy to remove the clay parts without damaging the mould. The trunnions holes were covered by tiles. The moulds were first made both sides open for removing the patterns and there was separate mould made for cascable [a projection behind the breech of muzzle-loading cannon]. Then they were joined together. This makes the mould complete. The mould was used for only once. The decorative patterns were made on wax and were fixed into the mould, when the mould was heated the wax melts, the design remained this design was then filled by the molten metal.

The other combined work of R.S. Khangarot and P.S. Nathawat describes that the moulds were prepared in split- pattern. The two half were joined together to make a complete mould. These moulds were made up of sand. This sand consisted of quartz, clay substance, feldspar, mica etc. The paste of the water and sand was made to form the mud. The inner layer was made by wooden beam. The inner surface was made smooth to inlay the patterns and design inside the mould, so that the design could appear on the surface of the cannon after cooling.

Then two half were joined together to make a complete mould. After that, the iron sleeves or bracing were wrapped so that mould could bear the pressure of molten metal, and an iron dish was used at the bottom for the support of the base.

In some parts of India Ironsmith preferred for the material for their barrels the iron of old sugar-boilers. But where this was not available, they used the spongy, cavernous and crude mass, which was the first reduced from the iron ore. Wood charcoal was used as a form of fuel. The forge was constructed exclusively for the barrel manufacture and was usually established at the gate of an oblong chamber, raised within the gunsmith's shops. The platform of this chamber was lower than the general level of the floor of the shops, by a few inches only at the gate, but it deepened by regular slop to the further end, making about a foot in difference between the front and the back. The sides and the end were closed by and the top by a vaulted roof, pierced by a vent-hole for smoke, which was diffused through the upper part of the shops and escaped by the roof and windows. The roof was generally horizontal.[57]

Stocks: The term stock in reference to firearms dates to 1571 is derived from the Germanic word *Stock*, meaning tree trunk, referring to the wooden nature of the gunstock. Stock is a component copied from crossbow.[58] A gunstock or often simply stock, the back portion of which also known as a shoulder stock, a butt-stock or simply a butt, is a part of a long gun that provides structural support, to which the barrel, action, and firing mechanism are attached. The stock also provides a means for the shooter to firmly brace the gun and easily aim with stability by being held against the user's shoulder when shooting the gun, and helps to counter muzzle rise by transmitting recoil straight into the shooter's body. Early hand cannons used a simple stick fitted into a socket in the breech end to provide a handle.

The modern gunstock shape began to evolve with the introduction of the harquebus, a matchlock with a longer barrel and an actual lock mechanism, unlike the hand-applied match of the hand cannon. Firing hand cannon requires careful application of the match while simultaneously aiming; the use of a matchlock handles the application of the slow match, freeing up a hand for support. With both hands available to aim, the harquebus could be braced with the shoulder, giving rise to the basic gunstock shape that has survived for over 500 years. This greatly improved the accuracy of the harquebus, to a level that would not be surpassed until the advent of rifled barrels. Indian Gun stocks were made of made of hardwoods, such as ebony, teak or palisander/ rosewood and the stock was ornamented of silver, gold, brass, lacquer or enamel.

Projectile:

Projectile is any object thrown into the space upon which the only acting force is the gravity. In other words, the primary force acting on a projectile is gravity. This doesn't necessarily mean that the other forces do not act on it, just that their effect is minimal compared to gravity. The path followed by a projectile is known as trajectory. A baseball batted or thrown and the instant the bullet exits the barrel of a gun are all examples of projectile. An object fired from a gun with an explosive propelling charge, such as a bullet, shell, rocket, or grenade is called Projectile. Generally a body projected or impelled forward, as through the air. Projectile weapons were mostly relatively primitive devices that accelerated and directed bullets or other solid objects toward a target to achieve damaging effects by direct application of kinetic energy. Hand-held projectile weapons were also known as firearms. Such weapons have been used by most species prior to the development of directed energy weapon technologies. Despite their "primitiveness", projectile weapons were still considered potent, effective, and reliable weapons by many civilizations. A **projectile** is a type of weapon that is propelled towards its target. If you fire a cannon, the cannonball is a **projectile**, but the cannon itself is not. When **projectile** refers to a weapon, it is always propelled by something else. Think of the bullet in a **gun** or a spear thrown by a person.

Ballistics:

Science of the propulsion, flight, and impact of projectiles are known as ballistics. It is divided into several disciplines. Internal and external ballistics, respectively, deal with the propulsion and the flight of projectiles. The transition between these two regimes is called intermediate ballistics. Terminal ballistics concerns the impact of projectiles; a separate category encompasses the wounding of personnel.[59] The study of firearms and firearm ballistics is often divided in internal, external and terminal ballistics. Internal ballistics refers to the processes inside the firearm, the minute space of time between the shooter pulling the trigger and the bullet exiting the muzzle of the gun. Following this, external ballistics deals with the bullet's flight between leaving the firearm and striking a target. Finally, terminal ballistics, also known as impact ballistics, refers to the study of the projectile striking a target.

Although there is a wide range of types of firearm, the basic theory behind how a projectile is fired is fairly generic the weapon aims to convert chemical energy into kinetic energy in order to expel a projectile from the firearm.

A round is first loaded and locked into the breach. This round consists of an outer cartridge case, a bullet, some form of propellant, and a percussion cap. The firing pin is generally mechanically restrained and, when the firearm is cocked, the firing pin spring is compressed. As the trigger is pulled, the hammer-mounted firing pin is forced forward to strike through a small hole in the breech face, hitting the primer cup. This contains a mixture of sensitive chemicals which rapidly burn, producing sufficient hot gases to ignite the propellant. As the gunpowder is ignited an expansion of gas occurs, which, confined in a small space, and eventually forces the bullet down the barrel of the firearm. Following discharge, a number of events regarding the used cartridge case may occur depending on the type of firearm. If the firearm is self-loading, a bolt will move back and pull the cartridge case out of the chamber, leading to it being ejected from the weapon. However in weapons such as revolvers, the cartridge will remain in the firearm until the shooter removes it.

The manner, in, which a firearm is loaded after each shot will vary, depending on the type of weapon. Some firearms are bolt action, meaning a bolt ejects the spent cartridge and, when pushing forward, picks up a new cartridge and places it in the chamber, cocking the trigger during this process. Manual actions firearms require manual reloading by means of a mechanical device such as lever or pump action. In recoil operated or blow back weapons; pressure generated by the ignited propellant drives back the bolt. Gas operated firearms include a gas port and, until the bullet has passed this point in the barrel, the bolt is locked. An amount of gas leaks into this port and unlocks the bolt, allowing it to move backwards. This ejects the spent cartridge case and loads another. Finally, in a revolving cylinder weapon, pressure on the trigger causes a cylinder containing the cartridges to rotate, positioning a new cartridge so that it may be fired.

Shotguns are available as either single-barrel of double-barrel. Single-barrel weapons can be further classified as single-shot, bolt-action, pump-action, lever-action or self-loading. Double-barrel shotguns encountered may contain a hinge at the barrel, allowing the shooter to open the weapon to reload cartridges. Both of these types of weapon are subject to having their barrel decreased by criminals, producing the "sawn-off" shotgun. The end of many shotgun barrels is designed to incorporate a feature known as the choke, which is a decrease in barrel diameter. This aims to focus the shot

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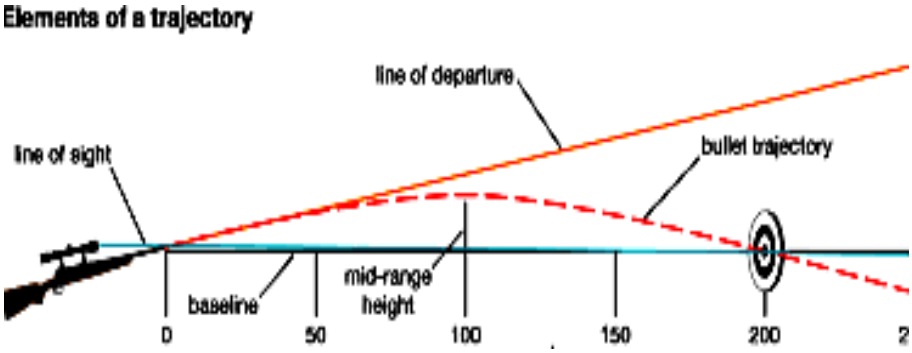
of pellets to ensure that they do not spread too much when fired. It is likely that different shotguns will express a difference degree of choke.



- **Cannon Ball:**

A round shot fired from a large-calibre gun is also called a cannonball. The cast iron cannonball was introduced by a French artillery engineer, Samuel J. Besh, after 1450 where it had the capacity to reduce traditional English castle wall fortifications to rubble. There are literary evidences to prove that cannons were used in the subcontinent in the fifteenth century AD, the first large scale use was by Babur in the First Battle of Panipat in 1526. Therefore, the use of cannon ball strike cannot be more than 500 years old, a period after early sixteenth century AD. Famous Kazan and Firingi of Babur threw only stone-balls. During the time of Humayun *Haft-josh* or alloy/ brass cannon-balls were occasionally used. [60] Same picture also can be seen in all over India. In north-East, Hard stone was also use to produce the cannon balls. Cannon balls were manufactured at Bhajani (Shibsagar) in Medieval Assam.[61]

In 17th century metallic cannon balls of slandered size was noticeable in Medieval India. Lead cannon balls were very popular in India in Mughal India.[62]

In the Peshwa period, some efforts were made by the Marathas to manufacture their own Artillery. Baji Rao started his own foundry. A Cannon ball factory was established at Ambegavan in 1765-66 during the administration of Madhav Rao I and four years later another factory was established at Poona for manufacturing cannons. These factories, however, produced a number of anti quoted guns of a style notoriously crude and clumsy, and the Marathas still steadily looked towards the Europeans for the supply of arms and ammunition.

Material	Density (g/cc)	Weight (kg)
Fe	7.87	7.18
Cu	8.96	8.16
Pb	11.35	10.36

- **Shells:**

The artillery shell was in use by the 15th century, at first as a simple container for metal or stone shot, which was dispersed by the bursting of the container after leaving the gun. Explosive shells came into use in the 16th century or perhaps even earlier. A shell is a payload-carrying projectile that, as opposed to shot, contains an explosive or other filling, though modern usage sometimes includes large solid projectiles properly termed shot. Originally, it was called a "bombshell", but "shell" has come to be unambiguous in a military context. Contact fuses rely on inertia of the shell driving a detonator against a pin, or vice-versa when the shell hits to explode the shell. The down side to this is that the shell has a few milliseconds to bury itself into the ground, and expends most of its energy throwing dirt in the air. I n 1801 a Gun Carriage Agency at Cossipore, Kolkata (presently known as Gun & Shell Factory, Cossipore) was established and production started from 18th March, 1802. This is the first Industrial establishment of Ordnance Factories which has continued its existence till date.[63]

During the 17th century European made shell became very popular ammunition among the Indian Princes. With the increasing popularity, European shells began to fetch high price. In January 1649, the Mughal authorities at Surat are

reported to have brought 'shots' from the local agents in very high rate. Within a decade [1659] company was advised to send as maximum as possible amount of shots to fulfil the demand. According to I. A. Khan, brass projectile were too costly for general use in the artillery. As a result despite the obvious advantages and greater efficiency of brass-shell/ wrought iron-shell, could never be adopted in the Mughal Empire.[64]

- **Bullet:**

Bullet is a kinetic projectile and the component of firearm ammunition that is expelled from the gun barrel during shooting. The term is from Middle French and originated as the diminutive of the word *boulle* (*boullet*), which means "small ball". Bullets are made of a variety of materials such as copper, lead, steel, polymer, rubber and even wax. They are available either singly as in muzzleloading and cap and ball firearms or as a component of paper cartridges, but much more commonly in the form of metallic cartridges.Bullets are made in varied shapes and constructions depending on the intended applications, including specialized functions such as hunting, target shooting, training and combat. Bullets are measured by their calibre, which indicates the interior diameter, or bore, of a gun barrel. Early bullets were round lead balls that were loaded down the muzzle of smoothbore weapons and propelled by the ignition of a physically separate charge of black powder. Modern bullets developed in the 19th century for use in small arms that had rifled barrels.

Though there were cast lead bullets used with slings thousands of years ago, the history of the modern bullet starts with the history of firearms. Sometime after A.D. 1249, it was realized that gunpowder could be used to fire projectiles out of the open end of a tube. The earliest firearms were large cannons, but personal firearms appeared in the mid-fourteenth century. Early projectiles were stone or metal objects that could fit down the barrel of the firearm, though lead and lead alloys (mixtures of metals) were the preferred materials by 1550. As manufacturing techniques improved, firearms and lead bullets became more uniform in size and were produced in distinct calibres.

The Industrial Revolution produced further improvements. Firearms with rifled barrels (spiral grooves inside of the firearm barrel that impart stabilizing spinning motion to the bullet) led to the familiar conical bullet. More powerful smokeless powders replaced gunpowder (now called black powder) in the late nineteenth century, but they also required harsher firearm and bullet materials. Lead bullets left lead residue in the barrel; jacketed bullets (a harder metal layer surrounds the softer lead core) were developed to stop this. The familiar metal ammunition cartridge (containing a bullet, a case, a primer, and a volume of propellant) was common by World War I.

Battlefield formation: Firearms

It is very difficult to state that what was the priority of the different branches of the Army (Artillery, Cavalry, Elephantry and Infantry) in the files of the fighting forces, but big and important battles the artillery occupied the first line of the vanguard. Heavy cannons were placed on big carts or carriages called 'Arabah'[65] which were linked together by iron chains and ropes of twisted leather. Between each pair of carts, there were placed six or seven gabions of nosebags full of earth or mentalist.[66]Deep ditches were also dug in front of the artillery to check the intrepid onset of the assailants. Entrenchment around the battle ground was also formed.[67] Next, the cart of artillery, there stood camels, which had behind them the rows of elephants. In the Qandahar Campaigns and rebellions which occurred during the reign of Shahjahan which the same system. The camels carried Shutarnal (camel-guns) and Zamburak (swivel- guns), and the elephants had on their backs- Gajnal and Hathnal (Elephant barrels). Each elephant carried two pieces of Gajnal and Hathnal and two soldiers. Behind the elephants was stationed the cavalry. The Cannoneers (Topchi), the gunners, the mortar bearers (Degandaz), the throwers of grenades (Rad-andaz) and the rocket-men (Takhsh- andaz) were generally in the vanguard, and on its two flanks. But the first row of the right wing and the left wings as the centre sometimes had also heavy artillery.[68] And so the elephants also were placed in front of each body of the troops. The cavalry always stood at some distance behind the elephants.

The Rajput cavalry forces fought chiefly with spears (Barchha) and the Mughal cavalry had mainly bows and arrows. On the left shoulder hung the shield (Sipar), which was taken into the grip of the left hand during encounters. The infantry was posted behind the cavalry.[69] The guns were tied to each other by ropes made of iron or cow-hides. Between every two pieces, room was left for the matchlock-men to fire their muskets from behind the cannon. The king or the Prince or the Sipahsalar, who commanded the troops, stood in the centre generally mounted on lofty elephant, clad in barb of steel and having a gaily ornamented Howdah and embroidered royal umbrella. He occupied a position which was visible from all parts of the field. The imperial standard fluttered either on his elephant or on the elephant standing just close to him. Other

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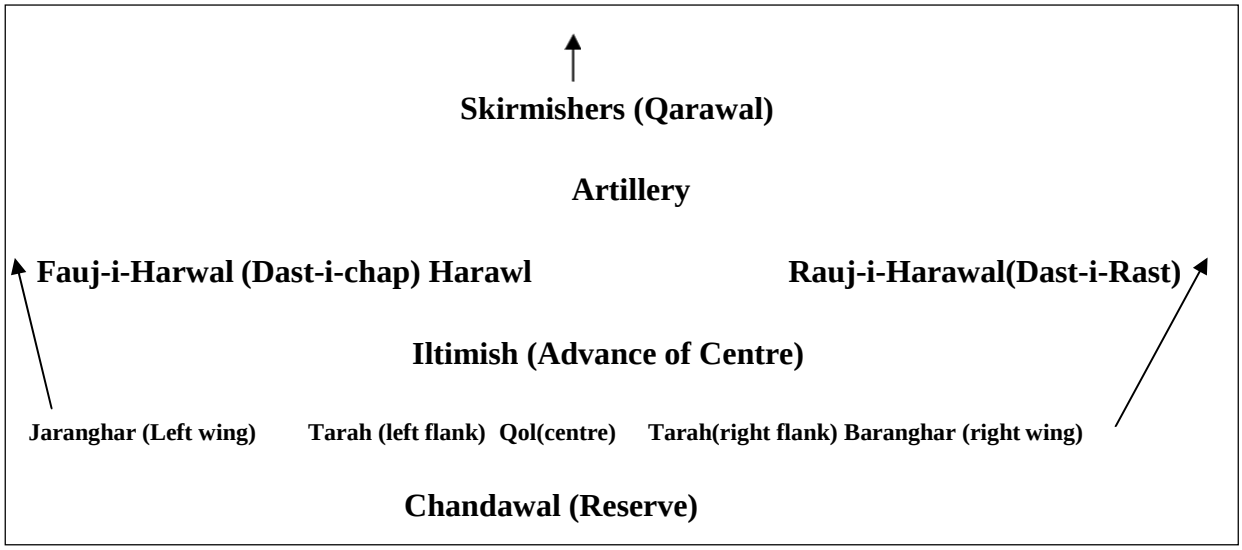
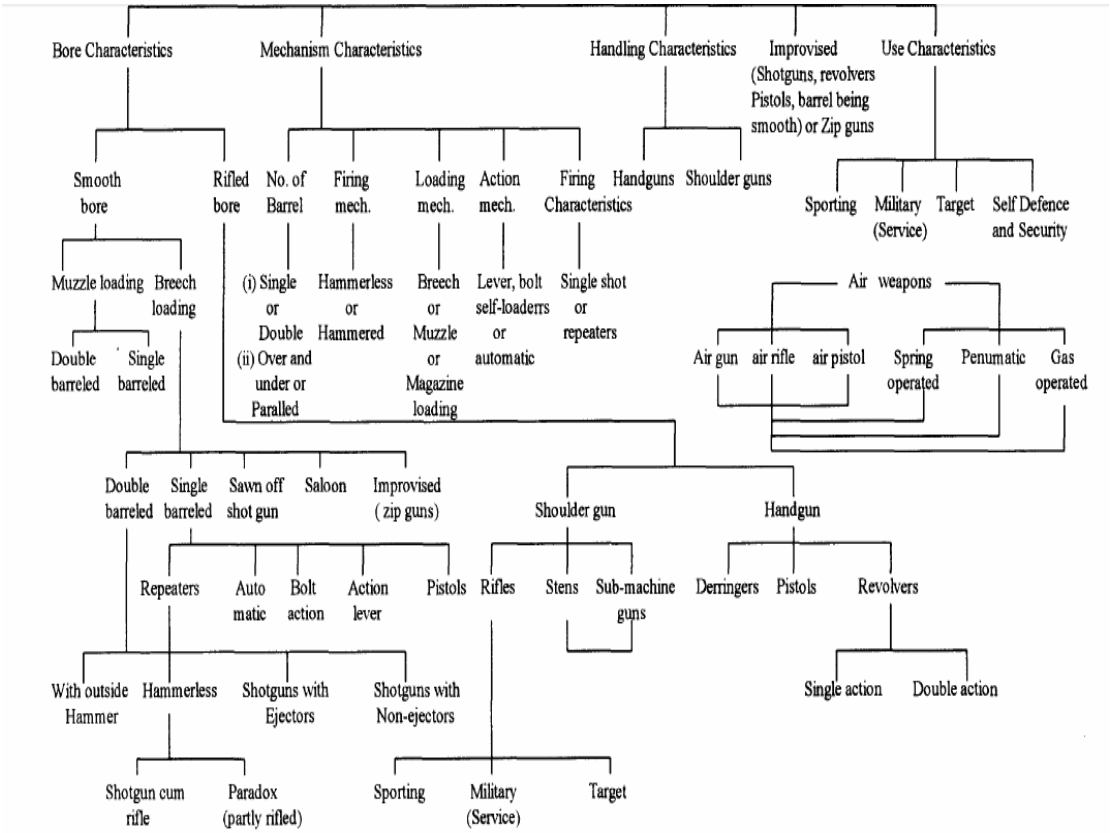
elephants in his proximity carried musical bands. When the king or the commander-in chief issued any order, they were conveyed to the different corners of the battle field by adjutants called *Tawwechi*. These adjutants also saw that every soldier remained at the proper place of his array. If this order was disobeyed the penalty was death. The rearguard was stationed at a short distance behind the centre. It watched against the onset of the enemy from behind, and looked after the camp and the royal harem.



Battle formation scatch (Baburnama, vol.I, pp.472-475)

Classification of Firearms



FOOT NOTES:

[1] Rahman, Trimurti: Science, Technology and Society, P.1, People's Publishing House,New Delhi,1972[I'm grateful to TIFR, Bombay for this book]

[2] Suniti kr. Chattopadhyay,p.48

[3] De La Garza, pp-114

[4] Yumi is the Japanese term for bows, and includes the longer daikyū and the shorter hankyū used in the practice of kyūdō, or Japanese archery. The yumi was an important weapon of the samurai warrior during the feudal period of Japan

[5] Hildinger, 24 [see in De la garza's bibliography]

[6] De La Garza, 114-19

[7] Bert Hall, *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology and Tactics* Baltimore: Johns Hopkins University, 1997

[8] *Ain-i-Akbari*, Volume 1, chpt. 89

[9] Asitesh Bhatacharya, "Gunpowder and its Applications in Ancient India", in Brenda J. Buchanan, ed., *Gunpowder, Explosives and the State: A Technological History*, Ashgate, Hampshire, 2006, p. 45

[10] Elliot, H.M., *History of India as Told by its Own Historians*, Vol. VI, Appendix A, pp. 481-82.

[11] *Rasarnava*, chapter IX, verse 2-3. Cf. P. Ray, ed., *History of Chemistry in Ancient and MedievalIndia*, Indian Chemical Society, Calcutta, 1956, p. 139.

[12] *Rasarnava*, Chapter XI, verse 83-86, Cf. P. Ray, op.cit., p. 139.

[13] *Rasa Ratna Samuccaya* by Vagbhata, edited with English translation by Damadar Joshi, in *IJHS* INSA, New Delhi.

[14] Gode, P.K., *Studies in Indian Culture History*, Vol. II, Collected Works Publication committee,Poona, 1960, pp. 43-44.

[15] Cf. Ray, P., op.cit., p. 225.

[16] *Ain-i Akbari*, translated by H. Blochmann, Vol. I, Low Price Publication, Delhi, 2001, p. 58.

[17] *Bayaz-i Khushbui*, I.O. 828, Rotograph no. 194, Department of History, A.M.U., Aligarh

[18] *Jahangir's India*: *The Remontrantie of Francisco Pelsaert*, tr. by W.H. Moreland and P. Geyl,IAD Oriental Series No. 8, Delhi: Idarah-i Adabiyat-i Delhi

[19] *Rasa Ratna Samuccaya* of Vagabhatta, ed. & tr. Damodar Joshi, Indian National Science Academy, New Delhi, 1987

[20] Ibid., p 115.

[21] Here *dhatuvada vidhi* specifically implies the use of sulphur in transmutation of metals. Ibid., p.97.

[22] *Rasarnava*, Book IV, Chapter VII, Verses 138-142. Cf. P. Ray, op.cit., p. 138

[23] *Rasarnavakalpa*, Mira Roy and B.V. Subarayappa eds., INSA, Delhi, p. 84

[24] *Ain-i Akbari*, Blochmann, tr., Vol. II, p. 132.

[25] *Bayaz-i Khushbui*, op.cit. , folio b, p. 149

[26] *Rasa Ratna Samuccaya* (tr.) Damodar Joshi, p. 294.

[27] Gode, P.K. maintains that the materials used in this type of charcoal are also mentioned in the Chinese text *Wu Pei Chih*

[28] P.K. Gode, 'The History of Fireworks in India between AD. 1400-1900, *Studies in Indian Cultural History*, Vol. II, Collected Works Publication Committee, Poona, 1960, pp. 43-44. [31] P. Ray, op.cit., p. 225.

[29] Sea-salt, black-salt, saline-salt, ammonium chloride, Romaka and potassium nitrate were the mentioned salts.

[30] Vijava Javant Deshpande, "History of Chemistry and Alchemy in India from Pre-historic to Pre-modern Times", in A. Rahman (ed.), *History of Indian Science, Technology and Culture AD1000-1800*, OUP, New Delhi, 1999, p. 141.

[31] P.K. Gode, 'The History of Fireworks in India Between A.D., 1400-1900, *Studies in Indian Culture History*, Vol. II, Collected Works Publication Committee, Poona, 1960, Pp. 43-44

[32] P. Ray, op.cit., p. 225.

[33] Vide E.S. Kennedy ed. and tr. Al-Biruni's *Kitab Tahdid al-Amakin*, Beirut, 1974, p. 3.

[34] Mira Roy, *Pyrotechnics*, p. 329.

[35] Afif, *Tarikh-i Firuz Shahi*, ed. Maulavi Vilayat Husain (Calcutta, 1890), pp. 365-7.

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[47] Ibid., P.94

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[57] Iqtidar Alam Khan, pp.111-113

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