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ARMS AND ARMOR IN THE AGE OF THE MUSKETEER

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1. Armor
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3. 17th Century

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Abstract

The 17th Century saw a great transition as gunpowder and firearms were being developed. This work researches the changes and trends set by the advancements of firearms, and the emergence of armies utilizing these firearms. Examination of sources from the 17th century, as well as inspection of artifacts dating from the 17th century housed in the Higgins Armory, is presented within the work as well as an internet site with an interactive feature highlighting regionally unique weapons and armor.

Introduction

The Higgins Armory Museum enjoys the distinction of being the only museum in the Western Hemisphere entirely devoted to the study and display of arms and armor. The museum offers a large collection of arms and armor from around the globe and from a wide range of time periods. The curatorial department of the museum wished to have their collection on display for a worldwide audience. This project is a portion of their plan.

The focus of our project is the Arms and Armor in the Age of the Musketeer (17th century Europe). During this time, arms and armor were evolving and simultaneously changing the social structure of Europe. This project consisted of a research report, the photographing of artifacts in the museum's collection, and finally a website devoted to the arms and armor of the 17th century (consistent with the museum's plan of an online collection).

The research report itself is divided into five parts – history, weaponry, armor, technology, and strategy.

It is in the Age of the Musketeer that the musket becomes the primary weapon for armies. The usage of firearms drastically changed the manner in which warfare was executed. Armies no longer needed lifelong-trained knights, and grew tremendously due to the ease of training. Battles now involved large masses of soldiers, inciting the need for large-scale organization and strategy.

Armor evolved as a result of the increasing firepower. Armor could no longer protect against the projectiles fired from pistols and muskets. Plate armor became largely

defunct in the late 1600s due to its cumbersome nature and its inability to protect the wearer. Its bulky nature proved to be more of a hindrance when mobility started to take precedence over protection, in conjunction with new military strategies.

Because of the growing use of firepower in armies, more efficient ways to produce materials were in demand. Defensive technology was also in need of innovation, as stronger materials had to be made as well as differently designed fortresses and siege campaigns.

A shift in primary offensive power was occurring, from hand to hand close-quarters combat involving extensive training to long-range firearms and artillery using moderately trained, less expensive commoners. Because of this shift, military strategy also changed. No longer would hand-to-hand combat be the focus in military training. Primarily, training would emphasize the use of muskets and long-range tactics and formations. Military training that had existed for centuries was totally revamped.

The widespread use of muskets also proved to be quite revolutionary. It allowed for the armament of the masses, in the English Civil War (1642-1651) one sees the first showing of rebellion that will mark the century to come.

This project also involved documenting the museum's artifacts. This phase of the project included the weighing, measuring, describing, and photographing of each artifact that had incomplete information. Altogether, out of the 548 artifacts from the 17th century in the museum's collection, about 150 artifacts were photographed and described in an eight-week period.

The final part of this project is a website for the museum, making the collection of artifacts from the 17th century available to a worldwide audience. The website contains

the research document, an online catalogue of the artifacts, and a representation of modern technology used to gain the viewer's attention and enthusiasm. The representation takes form in the manner of a computer game in which the viewer is tested to place artifacts with their respective region of origin.

The Thirty Years' War

By Ty Bailey

One can see from the onset that the Thirty Years' War is high drama at its finest. There are religious fanatics, spies, double crosses and double-double crosses. The largest lesson one can take from the war is that religion always takes the back burner to political gain. It is with this in mind that we begin to look at the causes of the war (or wars, depending on how you look at it).

There were many causes but the principal starting point is (like so may other conflicts) a treaty. The treaty of Augsburg was signed in 1555 in the hopes that it would stop further religious wars by allowing the recognition of Lutheranism in the Holy Roman Empire based on the concept of *cuius regio eius religio*, which roughly translates to "Who owns the land dictates the religion." It was also established that peasants were allowed to go to lands that shared their own faith. The treaty also stated that all property taken by Lutherans could remain theirs if it had been captured in the three-year period between the Peace of Passau and the treaty of Augsburg.

Instead of bringing about a mutual toleration of faith, the treaty actually caused a less visible but more dramatic schism in the Germanic lands. In the noble houses if one brother decided to leave, all of the estate would need to be parceled out, and this led to a great deal of strife and violence. The princes of many provinces saw that the treaty allowed them to secularize large amounts of the land that had once been given to the Church of Rome. In northern Germany, the secularization was nearly total and in the south, the only reason it did not take hold was the strong Catholic faith of the masses.

Needless to say, the Roman Church did not approve of this power play by the noble class and wished to gain back the land and power that it once held in the German states. The Catholic Church attempted return to the previous status quo by refusing to affirm the treaty of Augsburg in the General Council, which was held in Trent. By doing so, the Church opened up the floodgates for a loaded conflict of faith where the nobility saw a way to expand their authority and wealth while at the same time protecting their faith.

A few important foreign political players had an interest in German lands at the onset of the Thirty Years War. Arguably, the most influential of these was Spain. In 1555, Spain was being ruled by Phillip II. Phillip was a devout Catholic and absolute monarch, but most importantly, he was a Hapsburg. The Hapsburgs were very interested in helping the Church in Germany not only for religion but because their empire almost surrounded the French and territorial expansion into German soil would consolidate some of the gains they had made in the Netherlands; and if they could help the Vatican at the same time then all the better. The Spanish were in desperate straights for money; in fact, they went bankrupt in 1557, and also needed to secure their European power base so that they could better focus on their New World holdings.

The French were also interested in the German lands, mostly because they saw them as a way to block the ever-present menace of the Hapsburgs. In the eyes of the French, it was a far better idea to have wars fought on other nations' soil, and historically Germany has played the part of the battleground for the rest of Europe. It is with these players in mind that we begin to see the how much of a powder keg the Holy Roman Empire had become.

The first match was thrown in the city of Donauworth in 1606. A group of

Catholics was barred from holding a procession by the town's majority Lutheran population. A riot broke out and was only stopped by the direct intervention of Duke Maximilian I of Bavaria, a Catholic. By imperial decree, he was given the task of executing a ban on Donauworth. The Lutherans and especially the Calvinists in Germany became alarmed by this act and formed the Protestant Union in 1607. Maximilian I answered with the Catholic League. Already the Holy Roman Empire was splitting at the seams and all that was needed now was the final push over the edge.

The push came in the form of Ferdinand II. Ferdinand was made king of Bohemia in July of 1617 and vowed to rid his lands of heresy. He was approached by the Calvinists of Bohemia to confirm the letter of Majesty that was signed in 1609 which granted wide concession to Protestants. The king confirmed the letter but had absolutely no reason to follow through with it. In the following months, Protestant churches were destroyed in both Klostergrab and Braunau. The Protestants were shocked and on May 23, 1618, thirty men led by Count Matthias Thurn tossed two of Ferdinand II's representatives out of a window 70ft off the ground in the Hradcany Palace. This act came to be known as the Defenestration of Prague. After this, the Protestants deposed Ferdinand and put in his place Frederick V of the Palatinate on the 26th of August 1619. This is the start of the Bohemian Revolt and the true beginning of the Thirty Years' War.

Ferdinand II was not only the King of Bohemia, he was also the King of Hungary; and when the Holy Roman Emperor Matthias died without an heir apparent, he stepped up as the Emperor's cousin. On the 28th of August 1619, Ferdinand II was elected Holy Roman Emperor. At the same time, Count Thurn began a march to besiege Vienna and was joined by militants from Hungary, Moravia, Silesia, and Lusatia. In the east, Gabriel

Bethlen the Prince of Transylvania was leading a Protestant assault into Hapsburg-controlled Hungary. His assault was able to drive all the Hapsburg troops from Hungary and install Bethlen as king on October 19th 1619.

Ferdinand II knew that he needed support to put down this rebellion or else he would loose the imperial throne and open up the German lands to outside influence. He found four places to look for help: Bavaria, Saxony, Spain, and the Papacy. The Church of Rome would clearly support Ferdinand and give him what aid it could in the form of loans, mercenaries, or goods. More important though was getting Spanish help. Despite the financial problems of the empire, Phillip III was convinced by his minister to make a decisive stand for Bohemia. Phillip III ordered that a loan of 8.6 million ducats be given to Ferdinand II and that further Spain would support the Holy Roman Emperor with troops as well.

The same minister who convinced Phillip III of the importance of the conflict also was the one to persuade Saxony into the fray. Don Inigo Onate went to the Protestant Saxons and told them that if they assisted in the conflict on the side of the Ferdinand II then they would be given control over the lands of Lusatia and Silesia. Little more convincing was needed and Saxony joined the Spanish in the conflict.

Bavaria was harder to gain because Maximilian saw how strained the Emperor was and understood that the call to outsiders would not benefit the present nobility. He demanded that until he was repaid for his help, he would be given the title of Archduke of Austria. This was granted and a treaty was signed by the Emperor, Spain, and Bavaria on October 8th 1619. This was not the end of the deal however, for Maximilian also made a secret deal with Ferdinand II and demanded that his line be given large swaths of land in

the Palatinate and that they be given the title of elector. The Emperor had little else he could do but to accept the terms.

With all of his allies in place, Ferdinand II began his breaking of the rebellion. The Spanish used their might to block any support from coming in through France or the Netherlands so that the Protestant Union troops had no way of reinforcing the troops in Bohemia. Saxony invaded and pushed the rebellion back. But it was the Bavarians and the Catholic League who would bring down the hammer. B Bavaria had the most troops and with Spain, guarding its rear Maximilian had no fear of a sneak attack.

The decisive battle of the Bohemian rebellion occurred on November 7th 1620 near the White Mountain, five miles west of Prague. In a balanced pitched battle, Ferdinand II's troops routed the soldiers of Frederick V in roughly two hours and caused around 4,000 casualties as opposed the Catholics' 800. On the 22nd of January, 1621 the Emperor placed Frederick V under a ban of the Empire and gave his electoral seat to Maximilian of Bavaria. The loss of the battle and the overwhelming size of Ferdinand II's force also caused the slow dissolution of the Protestant Union. When Ferdinand II offered the rebelling Protestants, the freedom of worship and neutrality in further conflicts the remnants accepted quickly. With Austria back under control Ferdinand II was forced to pay the price of assistance. Spain was given a great deal of the Palatinate. Maximilian also wanted his section, and with the territory divided the people rose up against their new rulers and the conflict moved from Bohemia to the Palatinate.

Phillip III died in March of 1621; his son Phillip IV had the same goal for the holdings that had been gained in Germany. He wished to create a connection between their lands in Italy and their holdings in the Netherlands. He also remained heavily

committed to keeping a strong front in the German states because he felt that the Protestant movement in Germany could lead to a domino effect spreading southward unless contained.

In the Palatinate, the conflict was not as complex as it was in Bohemia. The conflict began when George of Baden-Durlach and Christian of Brunswick (known as Christian the Mad) recruited between them upwards of 50,000 men to fight the foreign Spanish in their territories and remove the Bavarian Maximilian. Opposing them was Johannes Tserclæs the Count of Tilly.

After a series of smaller engagements, George of Baden-Durlach was definitively beaten on May 6th 1622 by the combined forces of the Spanish and the Bavarians under control of Tilly. From the beginning, it was the hope of Christian that he would be able to join his army with the army of Ernest von Mansfeld, the undefeated general from the Netherlands, and move together to defeat the mutual Spanish foe. This did not happen, for as Christian moved his troops he was intercepted and defeated on June 20th 1622. Mansfeld fought on as best he could but without new troops it was all but hopeless.

On the 19th of September Tilly accepted the surrender of Heidelberg after a three-month siege. The fall of Mannheim followed on the second of November. Finally on the 6th of August 1623 what was left of the combined forces of Christian and Mansfeld were beaten at Stadholm. By 1624, Mansfeld's army was dispersed and the German conflict was at an end at least for a year.

The Danish Intervention

The next major event in the war came about because of the actions of Christian IV the king of Denmark. In May of 1625 Christian IV was elected to be the head of the Lower Saxony defense circle. He gained the title because he held the German province of Holstein, and was a Lutheran. His primary goal was to defend the circle against what he saw as a religious threat. He solicited England, France, and Holland; on December 9th 1625 they formed the Hague Alliance. As part of the agreement it was decided that if Christian IV was able to keep an active force of forty thousand on the field then the English would pay him a monthly sum of three hundred thousand florins.

These developments did not go unnoticed by Ferdinand II. Because Christian IV's alliance was slow to start, the Emperor was given time to prepare. On the 15th of July 1626, Ferdinand II allowed Maximilian of Bavaria to give the command to Tilly, which allowed him to cross the river Weser into Lower Saxony. At the same time Ferdinand II was making a deal with Albrecht von Wallenstein where Wallenstein would supply roughly 20,000 troops to Ferdinand II's cause for no cost other than that he be allowed to pillage the lands he went through. The emperor accepted and Wallenstein moved his troops west into Germany.

Albrecht scored first blood in the conflict by routing Mansfeld at the Bridge of Dessau and obliterating over half of his force. In Mansfeld's defense the imperial force led by Albrecht was more the twice the size of his army and also held the key ground. Sadly justifications get you nowhere in war and the remnants of Mansfeld's army were forced to hole up in Brandenburg until a truce was reached in October, and Mansfeld

ended his fight. He died a couple of months later, alone and utterly defeated.

The western front was going just as badly for the Protestant armies. Tilly had captured Göttingen in August and soundly decimated Christian IV at the battle of Lutter. From then on it was just a matter of time before Christian IV would be forced to give up. By December Christian IV was forced to withdraw to the protection of the Baltic Islands.

It was left to Albrecht von Wallenstein to complete the job. He already had accumulated a large war chest and had gained stature and rank in the empire. On his way to connect with Tilly's forces he had captured Mecklenburg, Pomerania, and Jutland. When he arrived and was given the task of finishing of Christian IV he knew he needed a fleet to cross the Baltic but there was only one city that had both the resources and the space required, and it belonged to Sweden.

The city's name was Stralsund and it managed to hold against a siege run by Wallenstein himself. It was quickly found that the city could not be taken because it was constantly being given provisions by both the Swedes and the Danish. Once Albrecht realized that continued force was futile he advised an end to hostilities. This led to the treaty of Lübeck, which was signed on July 7th 1629. The conditions of the peace were that Christian IV would give up his support for the Protestants in exchange for peace in Denmark.

Truthfully this would have been the end of the Thirty Years War if it were not for bad advice given to Ferdinand II by his Jesuit advisors, who convinced him that he needed to gain back all the lands lost to the church after the treaty of Augsburg. Ferdinand II decided to uphold the Edict of Restitution, which basically stated that only the Lutherans were protected under the treaty of Augsburg and that any other group who

had taken Catholic territory had done so illegally.

The edict was not received well by most of the nobility; even the great electors expressed doubts about its legality. At the electoral meeting in Regensburg in August of 1630 they decided that they would not elect Ferdinand II's son as heir to the throne. They also removed Wallenstein as an acting General, because of the cost and damage that his forces caused. They then lowered the size of both the imperial army and the Catholic League's army and appointed Tilly as the head of both so long as he kept them two distinct and separate entities.

It was during this time, when the Germans finally felt that the war was coming to an end, that a new player entered the game and brought with him a great deal of experience and wealth. Gustavus Adolphus was the king of Sweden and had just completed a fairly successful conflict with Poland and was now able to focus his efforts to help the Protestant cause in the now not-so-heavily-armed Germany. He was funded not only by Poland, as part of the peace, but also by Denmark and France by special concessions of Louis XIII.

The Swedish invasion of Germany began in late July of 1630 when Gustavus occupied the capital of Pomerania. He moved quickly and by January had managed to occupy the majority of Mecklenburg. His progress was halted when word came that Tilly and the Catholic troops had not only captured but slaughtered the city of Magdeburg. All told over twenty four thousand people were killed: men, women, and children, almost the entire population.

Tilly attempted to capitalize on the victory by attacking Gustavus directly but was quickly repulsed. He then, in what seems like madness, turned his forces towards Saxony

stating that a weak neutral party was unacceptable in the imperial conflict. When Tilly's forces entered Saxony they found that the king was not so great a fool as to roll over and accept defeat. On September the 11, 1631 Saxony officially joined with Sweden and Tilly's problems worsened.

Only six days later Tilly suffered defeat in the biggest pitched battle, up to that point, of the Thirty Years' War. At the battle of Breitenfeld, Gustavus and his Saxon cohorts managed in five hours to kill, capture, or scare off about one half of his thirty one thousand men.

Gustavus moved westward and by the 17th of December had crossed the Rhine. He wintered in Mainz and fortified his supply lines for the next season. When spring came fighting started immediately. Gustavus was faring well in Bavaria and was moving along with only small resistance from Tilly's forces. On the 15th of April, 1632 while taking heavy fire from Tilly's artillery, Gustavus's men managed to mortally wound Tilly and end his leadership of the imperial army. By May Gustavus had taken Munich and forced Maximilian to flee to Salzburg.

With Tilly dead, Ferdinand II had little choice but to bring forward Wallenstein and give him the task of not only rebuilding the army but also taking back all the lands that had thus far been lost to Gustavus. Wallenstein accepted and with a great amount of zeal not only got his new army but gained ground at a quick pace. By May, he had driven Gustavus out of Bohemia and forced him back to Nuremberg.

Once in Nuremberg Gustavus commanded that the defenses be increased and that earthworks be constructed. This it would turn out to be the worst thing he could do because it effectively cut off his supply lines. When Wallenstein arrived he simply

ordered that the city be besieged and to put it simply the siege worked well. After defeating Gustavus's army at Nuremberg, Wallenstein felt that the war was all but won and began to winter his army, but before he could get too far into the process Gustavus attacked for what would turn out to be the last time.

The battle of Lützen took place on November 16th, 1632 and was a technical win for the Protestant force. The battle was half the size of the battle of Breitenfeld but held a greater importance to the Swedish cause in the war. At the onset of the battle the imperial forces held a slight edge and Gustavus knew that for him to win he would have to quickly dislodge them from their defensive position before help could arrive. Before the imperialists withdrew Gustavus fell and so too did the Swedish hope for success in the German campaign.

Without Gustavus to lead, the Swedish army demanded all of their back pay and revolted when it was not available. A new commander tried to take control but after one battle was forced to give up the entire fight as a hopeless cause. The two sides of the conflict met shortly thereafter and more or less returned Germany to the way it was before Gustavus invaded but with one slight difference; Calvinism was now recognized by the state.

The French Intervention

After Gustavus was killed Ferdinand II send a command to Wallenstein ordering him to bring his army back into Bavaria. Wallenstein had no intention of stopping his advance, because it was very profitable, and instead of turning back he gathered his top

troops and attempted to have them swear a loyalty oath to him. Some of the high-ranking troops escaped his camp without taking the oath and sent word to Ferdinand II of what was transpiring. Ferdinand II then sent a new command to Wallenstein that stated quite simply that Wallenstein was no longer in command. After the command was received Wallenstein's army began to desert in droves. Finally on February 25th 1634, Wallenstein was assassinated by mercenaries while trying to flee from a townhouse in Cheb.

After Wallenstein's death Ferdinand II passed the command of the Imperial forces on to his cousin, the king of Hungary, Ferdinand III. Ferdinand III planned to assist the empire's Spanish allies by helping them take territory leading to the Netherlands.

By March of 1635 the combined Spanish and Imperial force had taken the city of Trier capturing Phillip-Christopher von Sötern. Sötern was an elector and also had put himself under French protection in 1632. When Cardinal de Richelieu, the chief advisor to the French king, received the news of Sötern's capture he convinced Louis XIII that now was the time to attack and stop the Spanish forces from encircling France. On May 26th 1635 France formally declared war on Spain.

Sadly for France they were not as combat ready as Richelieu had thought. By the end of 1635 the Imperial army had taken Heidelberg, Kaiserslautern, and Mainz. Even worse was the fact that on the instruction of Maximilian of Bavaria the Spanish troops executed a fast-paced invasion of French territory looting and burning all that was in their path. This tactic actually brought the Spanish within a hundred miles of Paris itself. With a great deal of luck Louis XIII was able to rally a small band of troops and have them successfully drive the invaders back far enough so that the regular army might be able to deal with them.

While this was transpiring Bernard Saxe-Weimar was promised a subsidy of one million livres annually and at the end of the conflict he would be given the Landgravate of Alsace. In return he would maintain a standing army of eighteen thousand. For two years all he could do was defend and hold the forested towns on the Rhine, but in 1638 he was given a real chance; when he was given reinforcements from the French he was able to properly siege the fortress of Breisach. The fortress was a key strategic location and extremely valuable but Saxe-Weimar would never see it in use. He died on July 11th 1639 and his second-in-command decided to swear allegiance to the French king.

Although many battles took place no force could gain a clear superiority. Things continued in this manner for two years until Lennart Torstennson was given command of what was left of the Swedish forces still in the conflict. He led his forces east and by the end of the 1642 he had taken control of Moravia and fortified the capital city Olomuoc to serve as the Swedish stronghold and staging ground for the duration of the war. The Swedes would continue to press into German soil until the decisive battle of Jankau in 1645.

By 1643 the French were also making headway into imperial lands. On May 19th Louis de Bourbon won a large victory at Rocroi and nearly annihilated the Spanish force protecting the area. By this time both Cardinal Richelieu and King Louis XIII had died; since Louis XIV was only five years of age, governmental matters were left in the hands of his regent Cardinal Mazarin, who wished to see an end to the conflict.

There were two more years of skirmishes before the last two major battles of the war, and another three years of less climactic fighting afterwards. The two major battles that finally brought the end of the war within sight were as follows. The first was the

battle of Jankau where Torstennson and his Swedish troops defeated the imperial army by attacking it in small piecemeal sections and scattering the imperial forces by continually splitting them. When the end of the battle came the last of Ferdinand II's forces were held up in Prague with little hope of escape. The other was the battle of Nördlingen where Louis de Bourbon defeated the Bavarian army of Maximilian. As was the case with the battle of Lützen, this battle was decided not by a total defeat but by driving an evenly matched opponent from the field. In fact the fight was so even that both sides lost virtually the same troops and when the Bavarians left the field the French were so weakened that they could not press the advantage to a decisive victory. Shortly after the battle Maximilian pressed for peace.

Although fighting continued until 1648, the peace process began in 1643 when the congress of Westphalia was officially opened. The reason that the peace process took so long was both because of a complex series of interests that needed to be taken into account and because no preliminary treaty was signed before the start of the congress. With no-cease fire everyone at the peace table prolonged the process as long as they could in the hopes of some great military victory that would allow them to have a greater say in the final peace.

As it became more apparent that France and Sweden were going to be triumphant, the Spanish emissaries conducted private peace negotiations with Sweden in the hopes of securing more mild terms then they would otherwise get from France. This was based on the fact that France wanted concessions of territory near Sweden and that it would be better for all involved if France were not to gain a strong foothold in the area. After peace was signed with Sweden, Spain negotiated an end to hostilities with France that left

neither party feeling as though they had made any gains.

But the same was not to be said for the terms that both Sweden and France acquired from the Holy Roman Empire. Sweden was given a vote on the Imperial Diet, the Bishoprics of Bermen and Stettin, Western Pomerania, and finally they were given control of the mouths of Elbe, Oder, and Weser rivers. France also gained a vote in the Imperial Diet, Alsace, Metz, Verdun, and Toul.

The biggest changes because of the Peace of Westphalia were to the German states themselves. There were several changes to the map and to who ruled in each area. Holland was recognized as an independent nation, as was Switzerland. But the truly large change was in the structure of the Empire. Now all the states in the Empire could conduct foreign policy with outside nations freely so long as they did not war against the Empire. This meant the end of any kind of unified Holy Roman Empire. It also meant the end of any chance that the Emperor had for consolidating his power and becoming an absolute monarch.

The Thirty Years' War was one of the bloodiest affairs of its time. When the peace was finally reached the citizenry of the Germany states had over 175 citywide celebrations. The war is also extremely important because it shows us why the German states did not follow the western tendency towards the unified nation state. We can also see where future conflicts can arise by studying the peace and understanding the long-term implications of both the divisions of the land and of the autonomy granted to the individual states within the Empire.

The English Civil War

By Ty Bailey

The English Civil War can be viewed as the precursor to the popular uprisings of the next century. Marx would see in the war a class struggle between the new urban plutocracy and the old landed gentry. This does not take everything into account however, because the events that led to the onset of civil war are hard to nail down and subject to a great deal of speculation. The sad truth is that many historians have found that the war was started by a series of blunders by both the king and the Parliament and that there was no overall method to the madness of the revolution.

Charles I was crowned the king of England and Scotland in 1625. He was a firm believer in the divine right of kings and that his power, in both church and state, were not to be questioned. He loathed to call on Parliament but when his military ventures in the latter part of the 1620s took a turn for the worse he was forced to call on them three times in order to gain much-needed funds.

The last of these three times was in 1628. The parliament not only refused to vote him funds but also brought forward legislation that he felt would undermine his authority. He disbanded the parliament and decided that they were no longer needed; thus began the personal rule of Charles I. He brought about taxes without the support of parliament and went about ruling as he saw fit and for a time it seemed to work.

The upper class were not thrilled with the way the king was excluding them from the governmental process but things seemed to be running smoothly and he was not doing anything against the rights of the people, so there was not any real large undercurrent of

dissidence.

But not all conflicts start because of repression of the rich. Charles I also felt that the Church of England needed to become more ritualistic and more awe inspiring and that it should integrate more with the church in Scotland. Most of the English citizens disliked the change in the church and felt that it was far too similar to the Church of Rome for their taste. In Scotland the reaction was far worse; they saw Charles I as a distant figure and not as a present force who understood their way of life and when he attempted to reverse the Scottish Reformation they elected to their parliament the Covenanters who in 1638 stripped the king of much of his power and influence in the north.

Charles I decided that the only way to re-assert his authority in the north was through military intervention and in 1639 marched his army into Scotland and initiated the Bishops' War. The conflict did not go at all well for Charles I mainly because his troops were under funded and less organized than their Scottish adversaries were. The king was forced to sign the treaty of Berwick in June of 1639. His hope was that by ending the conflict he could go back and gain much needed funds to strengthen his forces and then try again.

The kings ended his eleven-year absolute reign on April 15th, 1640, by calling on Parliament once again. The Short Parliament lasted less than a month but it was enough time for the king to realize that the eleven years had not dulled the liberal ideas of its members and so the king dissolved the parliament on the 5th of May, when it became clear that parliament was not for the war and would not grant him the money which he needed.

The king attempted to control the Scottish situation as best he could but fighting resumed and by August of 1640 the Scots had not only secured their own land but managed to push onto English soil and had completely routed the king's forces. Charles had no choice but to end the conflict in any way he could; so he signed the treaty of Ripon and as part of the treaty he was expected to pay the Scottish troops £850 a day until a permanent settlement was reached. The king could not afford this and was again forced to call on parliament, but this time parliament knew that the king had no other options and they intended to capitalize on this fact as much as possible.

The Long Parliament started off well. The players worked well together and presented a unified front while pushing through new laws that allowed for the strength of the parliament and the lessening of the king's might. Parliament quickly eliminated most of the changes that Charles I had instituted and removed from office most of his advisors or appointees that they found to be unworthy of such positions. They made it abundantly clear that from then on no new taxes could be put into place without parliamentary recognition, that the king could never again go more than three years without calling parliament, and that the king could not dissolve the parliament until the representatives themselves called an end to business. This effectively ended any chance for Charles I to ever again rule as an absolute monarch. All seemed to be going smoothly until October of 1641 when Ireland rebelled and parliament was forced to decide who held command over the troops of England.

Charles I held that the king was the usual commander of the military and all attempts otherwise had no basis in English history. The parliament never really argued the validity of the king's right to command the armed forces but they were split as to

whether or not they could trust the king in such a position. One side felt that the reforms put into place were enough and that the king deserved the trust of his people. The other felt that as soon as the king was again at the head of an army he would use it not to stop Ireland but to re-establish his rule and his powers.

At the height of the dispute, the split parliament issued the Grand Remonstrance, which outlined what the opponents of the king felt were his unlawful and abusive acts on the throne. In January of 1642, Charles I attempted to have five of the leading members of this group arrested for treason. The attempt failed and soon thereafter Charles I felt that he was no longer safe in London, because he saw that the town militia and the troops at the Tower of London were both loyal to parliament and not to him. He departed London and held his court in Hampton.

With the splitting of the opposing forces, the stage was set for eventual war. By the summer of 1642, both sides were starting to attempt to raise armies. There were a few skirmishes but very little open fighting. The king signaled the official start of the war by sending his family to the continent and then by declaring the parliamentarians as traitors; finally on the 22nd of August, 1642, he raised his standard and called for all men loyal to god and his country to come to his aid.

It was hoped by most people at the time that the war would end quickly in one large battle and that the country would once again be stable by Christmas of 1642. For a while it appeared as though this would, in fact, be the way things would work out. Both sides were amassing large armies and moving them in such a manner as to make it seem as if they would clash once to decide the entire conflict. On the 23rd of October 1642 the two forces met on the Warwickshire plain at Edgehill. The king initially held the high

ground, but soon moved down the hill because the parliamentarian army led by the Earl of Essex would not allow an engagement where he was on the low ground. Both forces had roughly fourteen thousand men and used similar tactics. By the end of the day neither side had won a conclusive victory. The next day the commanders eyed the prospects of continued battle but decided against it and they both left the field towards their respective goals.

The next two weeks looked as though the king would win the conflict, because every day he came, closer to London. By the 13th of November he was almost at the gates when the recently re-consolidated parliamentarian force blocked his way. The king decided that it was better to retreat than to attempt a strike against a force that heavily outnumbered his own. After this, Charles I wintered in Oxford, content in the prospects of the next campaign season. He held all the standard royal social functions and financed a series of propaganda works in the hopes of countering the parliamentarians influence.

When fighting again started early in 1643 it went well for Charles I. The king's troops gained ground in all directions and soon London was again vulnerable. Charles I also negotiated a peace with the rebelling Irish, thereby giving him more troops to work with. This peace had more negative than positive consequences though. By maintaining peace with the Irish Catholics Charles I antagonized a great deal of his subjects and directly led to the Solemn League and Covenant between the Scots and parliament, which formed in September of 1643.

By February of 1644, the Scots sent twenty-two thousand men across the Tweed and began to destroy the weak northern royalist forces. The king tried to keep his ground but the combined might of the Scots and parliamentarians left him with very little real

chance. On July 2nd 1644, the largest battle of the first civil war took place on Marston Moor, where eighteen thousand royalists fought against twenty-eight thousand parliamentarians. The Royalists put up a good fight but in the end the parliamentarian cavalry led by Oliver Cromwell broke the line and within two hours the royalists were decisively defeated.

At the same time that this was happening parliament was again split as it decided how it should handle its newfound position of dominance in the conflict. The Independents felt that the war should be decisively won and the Presbyterians wished to make peace with the king and return to the normal state of affairs. The Independents won out and issued the Self-Denying Ordinance, which barred the nobility from holding high posts in the military because it was felt that they were not going for the decisive win. It is of importance to note that Oliver Cromwell was the lone person exempt from the Ordinance because parliament felt that his leadership was far to valuable to be gotten rid of. They then re-built the army under the title of the "New Model Army" which took on the responsibility of ending the conflict with the king.

By the end of 1645 the royal armies were scattered and weak. The parliamentarians were simply mopping up what was left of resistance. Charles I surrendered himself to the Scots on May 5th 1646. The surrender of the king signaled the end of the first civil war but only the start of the chaos that ended in regicide.

While in Scottish hands the king tried his best to play politics while he secretly met with the French who he hoped would give him military aid. He also was presented with the Newcastle Propositions. The propositions were meant to be the basis for a peace and the most important of the points made in them were: Episcopacy was to be ended, the

army and navy were to be under parliamentary control for twenty years, and the Irish cessation was to be annulled and the war with Ireland would be directed by parliament.

The king found all the terms completely out of the question but pretended to play along to stall the inevitable. In February, 1647, the Scots became tired of the kings games and gave him over to parliament while at the same time withdrawing their troops from English soil. This did not however mean that they were done with English affairs. By the end of the year, the Scottish would once more be ready to fight and this time it would be on the side of Charles I.

While Parliament discussed the best course of action to take with the king it became apparent that the Independents were gaining a stronger hold in office and the New Model Army was becoming more radical. Parliament decided they would give the king a final chance to make peace and return to London. He was given four bills, which contained what were essentially the most crucial points of the Newcastle Propositions. On the 28th of December 1647 he rejected them and at the same time finished negotiations with the Scots that would allow him to spark a second civil war.

Charles I signed the Engagement on November 13th 1647; the basic deal was that Scotland would attack England in exchange for the king imposing Presbyterianism on his English subjects for three years, and he would grant Scotsmen a greater say in English affairs with the eventual goal of combining the two states. Although the deal was accepted by Scotland, many of its inhabitants felt that any deal made with a man who was not himself a Presbyterian, was suspect. When the Covenanters attempted to recruit for this new conflict, they were hampered by religious leaders who preached against the Engagement. They so held back that by July they had only gained nine thousand troops,

most of whom were untrained and untested.

While the Scots were recruiting, Parliament was deciding its next move. Many of the members felt that the time for negotiation had passed and demanded that the king be forced to accept any peace that Parliament deemed necessary. The House of Lords did not wish to see the Vote of No Address passed, but was forced to do so when members of the House of Commons arranged to have troops moved into Whitehall for the "Protection" of the members. The Vote was passed on February 11th 1648, and with it the Parliament declared that it would see to the government as it saw fit, and that the king was no longer to be trusted.

Compared to the first civil war the second was both short and one-sided. It was clear from the onset that the king lacked popular support and that the Scottish army was both too small and too poorly trained to put up any real fight. When the Scottish were finally ready in August of 1648, so too was Cromwell and the New Model Army. On the 17th of August the two groups clashed in the battle of Preston. The battle was more of a running engagement that lasted until the 19th when the utterly defeated Scots made a last stand at Winwick but were quickly beaten by Cromwell.

Again, the king was beaten and captured. He was held at Newport on the Isle of Wight. Parliament wished to attempt negotiation one last time, and sent 15 members to the king in the hope that the conflict could finally be resolved. They began negotiations on the 18th of September 1648, and it was clearly stated that the negotiations would only go on for forty days at the most. The king made it appear as if he was legitimately interested in the Treaty of Newport, while he secretly made plans for escape. The forty days passed without a firm conclusion, so the 15 members returned to Parliament without

reaching a final peace.

While the negotiations at Newport were being held, Parliament was debating the Remonstrance of the Army, which stated, amongst other things, that Charles I should be put on trial for his crimes and that the Army should be given all its back pay. Parliament voted the Remonstrance down when the Members returned from talks with the king. This is when the Army decided that Parliament, as it currently stood, was no longer capable of proper action, and that the time had come for the Military to intervene.

It started on the 1st of December when the king was moved to a far more secured location, which removed his chance for escape. One day after moving the king, the Army moved into London with complete dissolution of Parliament in mind. For the next five days the high officers met with the Independents in the House of Commons and it was decided that the best course of action would be to purge the Parliament of those who would interfere with the agenda of the Army and the Independents.

Pride's Purge (so called because the leader of the purge was Colonel Thomas Pride) occurred on the 6th of December. Pride stationed his troops around the House of Commons and blocked the entry of over one hundred and forty members of Parliament. In the end there were only fifty-six members left in the House and all of them were firmly in the pockets of the New Model Army. The first thing that this "Rump" Parliament did was to accept the Remonstrance of the Army, and then after one last attempt to deal with the king, Cromwell finally gave up on the king and it was decided that a trial must take place.

On January 1st 1649, the Rump Parliament passed legislation for a special court with the purpose of the trial of Charles I. The House of Lords rejected the ordinance; in

response the Rump Parliament declared itself the highest authority in the land, and again passed the ordinance. The trial opened on the 20th of January and lasted only seven days, and on the 27th the king was convicted and sentenced to death. Three days later he was brought to a specially built scaffold, and with quiet dignity Charles I went to the executors and was beheaded.

After the execution of the king, changes occurred quickly, by February 7th, the Rump Parliament had abolished both the House of Lords and the Monarchy. In the place of the king Parliament created the Council of State, which was to be elected and would act as the executioners of the Parliament's policy. This council declared the Commonwealth, which in theory made England a democratic republic, and gave legitimacy to the revolution in Parliament. In the moths that followed Parliament passed a series of acts aimed at strengthening the claim they had made to government. The first was the Engagement Act, which passed January 2nd 1650 and stated that all males must declare their loyalty to the Commonwealth. The next was Treason Act, which was passed on the 17th, and decreed that even to question the legitimacy of the government would be, grounds for high treason and execution.

Although Parliament felt that the war was all but concluded there was still the question of regaining peace in Ireland and Scotland. To subdue the Irish, Cromwell led a very successful and very violent series of offensives against the rebels and forced them into submission. He then put into place a puppet government that would bow to England's will. As for Scotland the fight was longer and more complex because the Scottish had never abandoned the Monarchy.

On January 1st 1651, Charles II was crowned at Scone. With his coronation the

Scots firmly showed that they were against the Commonwealth. Cromwell led another offensive against the Scots but found that the Scottish leaders refused to engage in a pitched battle. He decided that the best course of action would be to feign an assault to the northeast so that the Scots would go deeply into English territory and when they were far enough into the heart of England, they would route them and force combat. The plan worked flawlessly and on September 3rd 1651, the Scots and what was left of the English Royalists lost at the battle of Worcester. This would turn out to be the final conflict of the English Civil War, after this point all the revolutionary changes would occur within the state, without pitched battles or supply lines.

In the next two years Cromwell strengthened his hold on both the military and Parliament. He found that by early December 1653, the Rump Parliament was being split up by opposing factions that he felt were either too conservative or too liberal. He found that this was hindering the ability of Parliament to successfully govern the country and that a strong executive was needed for the smooth operation of government. To this end he drafted the Instrument of Government and with military backing forced its acceptance.

The Instrument was one of the first documents that attempted to set forward what the powers and responsibilities of each branch of government would be. It stated that the government's executive power would be held by the Lord Protector and the Council of State. It held that no more the three years without being called, the Parliament could not be dissolved or dismissed with out the consent of the members, the executive would be in control of the military, and finally that there would be religious toleration for all Christian based groups except for Quakers, Catholics, and Episcopalians. Cromwell assumed the position of Lord Protector on December 16th 1653 and for slightly over a year

government functioned as the Instrument envisioned.

In that year Parliament debated the Instrument and the members became embroiled in a debate about whether Cromwell should get more or less power as Lord Protector. As the debate intensified, Cromwell asked the body to retire and they refused. After this Cromwell entered the House of Commons and brought with him his troops. He declared the Long Parliament dissolved and had the members removed. Thus the war went full circle, now Cromwell was to be the absolute monarch.

Cromwell's rule was plagued by conflict both inside and outside of the Protectorate. In a matter of three years, there was war with Spain, France, and Holland, not to mention further uprisings by royalist sympathizers. Cromwell found himself in a similar situation to that of the late king Charles I when he ruled alone: war was drying up the treasury and weakening his position within the state.

In September of 1656 Parliament was again assembled, this time with a clear understanding of the limits to which it was allowed to function. In truth the popular opinion had shifted in the year and it was clear that most of the nation missed a true monarch. To that end Parliament drafted the Humble Petition and Advice, which offered the crown to Cromwell. This was not a move to strengthen the executive, but was in fact a way to limit Cromwell's control by using royal precedents. Cromwell saw this and decided to formally reject the proposal on May 8th 1657 based on the ground that he was not truly a king and did not wish to be. Parliament reacted by reworking the document so that the basic principles and controls remained but the title of king was removed. This new Petition was presented to Cromwell on the 25th of May 1657. He accepted the Petition and on the 26th of June in a ceremony that was a coronation in all but name.

For all intents and purposes Cromwell was now the monarch of England.

What followed was a year of relative peace and stability, and finally on September 3rd 1658, Oliver Cromwell died. He left the Protectorate in the hand of his less than capable son Richard Cromwell. Richard was not as strong a leader as his father was and he lacked the one thing that kept Oliver Cromwell in power; and that was the loyalty of the Army. In fact after his handling of the third Protectorate Parliament, the generals of the Army decided that it was about time to end the Protectorate and re-instate a representative executive branch. On April 22nd 1659, Richard was forced to dissolve the Parliament of the Protectorate, and replace it by the Rump Parliament, which retook its place of power on the 7th of May.

The first thing that the Rump did was to elect a new Council of State. Immediately after on the 24th of May, Parliament forced the resignation of Richard Cromwell after refusing to recognize the legality of the Protectorate. As complex and fast-paced as the changes occurred after the first civil war, the next year was far more intense.

Major-General Lambert was against the elimination of the Protectorate and when news reached him, he marched into London and on the 13th of October forced the Rump Parliament to step down. He then removed the Council of State and put into place a committee of safety made up of Army leaders. This action was massively unpopular and when Lambert left to confront northern military action against him, London erupted in civil disorder and this new committee was forced to step down through free of internal and external strife. For a matter of ten days in December of 1659, England was utterly without a government.

On the 27th of December 1659, Major-General Fleetwood was able to bring enough order back to London that the Rump Parliament was able to assemble. By March Major-General Lambert had been defeated and brought as a prisoner back to London. After Lambert was taken care of the military near London intervened on the Rump Parliament and forced it to accept those members who had been removed since Pride's Purge. On March 16th 1660 the Parliament called for open elections and then disbanded. In the election that followed the results were overwhelmingly pro-royalist and it is then that Charles II made his pitch to return as sovereign.

April 4th 1660, Charles II released his Declaration of Breda in the hopes of regaining his kingdom and finally stabilizing the state. The declaration stated that the king would pardon and give amnesty to all offenses during the civil wars, except to those involved in the regicide. It also stated that otherwise the details of restoration would be handled upon acceptance of the declaration. The declaration was received well by both Parliament and the masses. On May 8th 1660, Parliament formally accepted the declaration and declared that Charles II was the rightful king; and in fact had been the rightful king since the 30th of January 1649. On May 29th Charles II entered London and peacefully retook the throne.

One might look back and think that the revolution failed, but it had far reaching Social and political effects. The war was the first model of a popular uprising; the reason it didn't take was primarily because the majority of the population was not yet prepared for the move from a traditional Monarchical state to a Liberal Republic.

17th Century Commerce and Conflict

By Ty Bailey

The 17th Century was a transitional period for the great states of Europe. It was a century that can be best described with one word, Centralization. This was the century that brought us the absolute monarchs and the concept of a nation-sate in the manner that we think of it today. The true question of this era is why was there such change, and how was this change accomplished. To answer them both one needs to understand the nature of the state and the rise of capital.

After the fall of the Roman Empire, the states of Europe had functioned, more or less, around a hierarchical system of militaristic support known as the feudal levy. This levy, in theory, laid down a structure in which a king could call upon all those below him in the chain of nobility for military aid. This system had several drawbacks, the biggest of which was that there was no protection for the king in the event that all of the lower nobility did not heed the call to arms.

The kings saw this and over time found that the best way to ensure that they would be both safe as a monarch and able to have their commands obeyed was to have a personal standing army that was capable of both handling the local-level problems and enforcing the king's will on any of the other nobles who might not wish to fall in line. But for the king to have a standing military force that was not of the landed nobility, he would have to pay for the troops in forms other than land or exemptions; in other words the king was forced to use bullion. The rise of a bullion-based system of commerce is beyond the scope of this paper but it is to be assumed that by the start of the 17th century,

most of Europe had moved away from the barter system and into trade based on state sponsored currency.

By the start of the 17th century the great kings had amassed enough wealth to monopolize the coercive power of the state, and had taken the reins as the sole executive of the state. The best examples of these absolute monarchs were Louis XIV of France, Charles I and later Oliver Cromwell of England, and finally Phillip III of Spain. These rulers had their strength based on the power and loyalty of their armies and on the strength of their agents in the courts of the lesser nobility.

It was felt at the time that the measure of the strength of a state and by connection the monarch was directly connected to the amount of bullion within its treasury. To this end the monarchs sought a way to control the system of trade within the state so that they would receive a greater amount of the bullion in the economy. It was with this in mind that the economic theory of Mercantilism came into being. The general idea of the Mercantilist system is to hold as much bullion within the state as possible while at the same time taking the bullion from other nations. This combined with taxation would leave the monarch with a generous supply of funds, which they could then use, within the state on projects of their choosing.

The problem with this system arose when all of the nations of Europe adopted it. When this happened it became apparent that no new bullion would enter the system without the use of new sources of commerce. These sources would have to come from controlled foreign states or private colonies so as to not allow the other great nations of Europe the chance to profit from them.

Initially Spain was the front-runner in this system and for a couple hundred years

became the dominant force in Europe, thanks mostly to its New World colonies and the amount of raw material and precious metals that they brought in. However by the 17th century Spain's power and influence was on the decline. Spain attempted to maintain its strength throughout the century but it lost its hold because of a series of bad events and poor leadership. Philip III did not know how to manage overseas colonies, while massive corruption and the lack of new bullion-producing ventures left the king with little in the treasury.

Upon Philip III's death his son Philip IV continued the ill-advised wars of his father; he attempted to defeat the Dutch in 1621 and was beaten when they allied themselves with both France and Sweden in 1630. In the end the reality was that Spain refused to change with the times. Although Spain had a complete monopoly of trade with its colonies, it could have been better off if it allowed private ventures to develop a more competitive and in the long run profitable internal trade system.

France on the other hand attempted to change the way it viewed financial matters under the reign of Louis XIV. Louis' superintendent of Royal finances was Jean Colbert, and under his eye the French state attempted to create a very strong mercantilist economy where the crown could tax and would buy into ventures so that it might profit in both directions. Colbert strove to eliminate the French debt so that the king would have a better chance for future loans. He aggressively sought noble backing in the commerce of independent companies for the purpose of strengthening the noble position within the young economic system. Colbert did not support farming more than needed because he felt that the future would be in manufacturing.

Colbert attempted to expand France's economic base through intense colonization

and maritime strength. He expanded the French navy and made it publicly known that there were rewards for those who sank or captured Dutch vessels. Colbert almost doubled the size of the navy and made it a force capable of holding its own against any other current naval force. The only thing that kept France's mercantile power from becoming a dominant force in Europe was the fact that it could not set up a profitable colony or trading company.

All of the companies that the French state backed were little more than government extensions with very little freedom. All aspects of company policy, income, and goals were controlled by officials of the state and in the long run there was very little in the way of public motivation to fund any of the new ventures. Those who did work on the colonial ventures found new problems in trying to get people to move to the colonies. Unlike the English colonies there was no real motivation, religious or political, that was a strong enough to make the general population wish to leave. Even if there was strong push to move there was very little reason to because the French state held a strong hand in colonial government and administration. In the end it can be viewed that although France did better than Spain at a profitable mercantile economy it too failed to gain a strong position in trade mostly because of too much central control, which in turn limited the amount of interest by the population.

Colbert felt differently. He always thought that the reason for France's problems came from the Dutch, and to some extent he was correct. The United Provinces had spent the majority of the previous century gaining balance as a republic and building up its reputation as a seafaring people. The government was decentralized and allowed a wide breadth compared to its other European rivals. They were a federation with mutual

trade and protection alliances; this gave them less of an overall control by the government and gave them the freedom to follow through on individual pursuits. They made heavy use of innovation to increase the speed and quality of their vessels, which in turn allowed them to have a greater reach for trade routes.

In March 20th, 1602 the first public stock company was formed. The Dutch East India Company held what amounted to a government-sponsored monopoly for trade with all of the United Province's Asian holdings. At its height the company was the richest private organization in the world. It had over 150 merchant vessels, 40 warships, a private army numbering in excess of 10,000, and provided jobs of some form to 40,000 others. But this much success came at the price of being hounded by all the other nations of Europe. Other then the continuous piracy of France and Spain the Dutch were in a constant rivalry and sometimes open conflict with England.

By 1650 the Dutch had already started on a slow downward trend. The English felt that they could force the collapse of the Dutch trade system by not allowing any trade to take place that was not on English vessels. Needless to say, the Dutch did not feel that this was a legitimate law or that the English had any power over who could use the sea. The insult of the Navigation Act was compounded by the capture of twenty-seven Dutch trading ships by the English in Barbados. In response the Dutch officially ordered the outfitting of 150 merchant vessels for war, and for the expansion of the navy.

News of the expansion reached Cromwell and the British Commonwealth on the twelfth of March 1652, and it was decided that the British should prepare in kind. Neither side was ready for a large-scale conflict, it was hoped that they would be given the proper time so that they could get their respective navies in working order. This

would not be the case, on the twenty-ninth of May 1652, Maarten Tromp refused to dip his flag in salute of the British, and because of this breach of British law, Robert Blake opened fire on the Dutch.

The war officially began on the tenth of July 1652. Within the first month, the English had shown naval supremacy. Within six months the British felt that the Dutch were all but beaten and sent many of its ships to the Mediterranean as re-enforcements. The British chose poorly because the Dutch were still working as best they could to increase their naval strength. Their efforts proved successful when, in early 1653, they won a series of battles and effectively blockaded the British into their ports.

The success was not to last however; On the twenty-eighth of February 1653, the British broke through the Dutch in the battle of Portland and in a series of major victories, pushed the Dutch back to their own ports. It became apparent to the Dutch that the war was coming to an end and after one more desperate attempt to break the British line the Dutch went to the negotiation table.

The peace was signed on the fifth of April, 1654. The terms were rather simple, the Dutch would recognize the Commonwealth, and that they would also recognize the Navigation Act. One thing the treaty lacked was how the associated corporations from each country would treat each other for they had armies of their own. Not settling this part of the conflict is one of the major reasons for the second Anglo-Dutch war.

After the Restoration, England was in a highly energetic and nationalistic state. There was major anti-Dutch sentiment. This combined with the fact that the Dutch were undercutting the British in the slave trade caused the British to capture two ports in West Africa and the city of New Amsterdam (New York) in January of 1665. After the start of

the conflict, the British kept what would be seen as the upper hand and controlled the majority of the major trade routes. But by 1666, the Dutch had made the rest of the major states of Europe their ally and were turning out seven ships to ever one the British produced.

On June 11, 1666 the two fleets met in the epic four days battle. Over 130 ships engaged in the battle and the end came only after both sides had expended most of their ammunition. Both sides claimed victory; the British claimed it because the Dutch had been the first to retreat. The Dutch claimed the win because they had sank seventeen British vessels and killed over a thousand sailors, as well as two admirals. The British re-grouped and managed to win many smaller victories before the king was forced to sue for peace because of lack of funds. But before the peace could be reached the Dutch won one last assault. The raid on Medway occurred on the June 13, 1667. The Dutch moved their fleet up the Thames and raided the town of Medway after defeating the British defenses. This was the greatest military defeat for England since the Norman invasion.

The peace was quick and the British conceded defeat. The Dutch received most of their land back with the exception of New Amsterdam, which they traded for Suriname. Though there was a third Anglo-Dutch war it had little to do with globalization or economic factors.

One can see that the seventeenth century was a time of change for Europe. The old kingdoms were being divided into two camps, those who understood the power of foreign market and those who didn't. It would be shown soon after that only those who were willing to work in a free trade system would be able to keep their national economic strength.

A General History of Technology in the 17th Century

By Miguel Adelino

The 17th century was a time of great technological advancement. 17th century Europe was right in the middle of the Scientific Revolution and just on the cusp of the English Industrial Revolution. Innovation was brought on by a need for energized industry. Bigger industry meant more money, so improvements, and refinements on designs and processes were essential for any entrepreneur. In mining, water pumps and air pumps were being developed and refined to pump water out of mines and air into them; and rail systems were devised for smoother transportation of materials and laborers. In manufacturing, waterwheel powered bellows made better blast furnaces and lathe machinists were able to manufacture screws for machinery. The advancements made in this century would help usher in the new age of powered machinery and mass production.

Agriculture was in the process of becoming revamped in the 17th century. New farming techniques and crop rotations were being developed like the four-year crop rotation. This technique would rotate fields using wheat, barley, turnips, and clover. When a field was out of season, it would be used to grazing purposes, thereby increasing the efficiency of land use. Irrigation processes were also becoming refined with new methods using the dam, the noria, and the ganat. Because of the increasing power of the state, and the ideas of expanding trade and mercantilism, agriculture was becoming centered in the places optimal for a large output, ones that could handle the demands of Europe. An example of which would be the Mediterranean grain fields. These fields had

always been enough to support the local economies and peoples, however, they could not compare with the fields of eastern Germany and Poland. Therefore, these Mediterranean fields were used less, and trade with foreign nations surged. Because of these new trends, the common farmer and artisan would become a skilled laborer, contracting his skills to the nearest company.

Water was a very useful tool mostly used in irrigation. Hydraulics had been used primarily in Holland, obviously because of the need for dikes and water engineers. In Italy, advances were being made in hydraulic technology, specifically through pile dikes, masonry walls, stone pitching, mattress, and fascine work. These were prime examples of static water technology of the time.

Water could also be used to power rotating work otherwise done by humans and animals. Water would turn a flywheel, whose shaft would rotate gears. Bars and beams would also be placed on the wheels' surfaces to provide cranking motions that could be applied to grinding and pounding equipment in mills for example. Waterwheels were an established form of energy useful as a means to rotate grinding stones in mills for flour as well as pumps and other machines. With just a source of flowing water, mills could operate with less manpower and yield products faster and in greater quantities. Different types of waterwheels were employed, namely the overshot, the undershot, and the horizontal. This was the beginning of powered technology.

Steam power had been explored as early as Hero of Alexandria (c. 50 C.E.); however its applications were never taken very seriously. Most steam applications were mere toys used to awe children and those who did not understand forces and physics. During the Renaissance, inventors such as Leonardo da Vinci, Baptista Porta and David

Ramseye toyed with ideas for applications of steam power, specifically to raise water from low points to high points without the use of horse or manpower. These ideas would soon become public.

In 1663 Edward Somerset, the second Marquis of Worcester, published *A Century of the Names and Scantlings of Inventions by me already practised*. In it he described a steam-powered engine that would raise water for useful purposes. His book contained no diagrams, but engines were designed and created based on his description. His engine was a more elaborate form of Solomon de Caus' machine for raising water using steam's expansive properties. The Marquis obtained the rights for his "water commanding engine" in 1663. His engine, comprised of two vessels, a boiler and a water source, was the first known attempt to make a practical use of steam power. Sadly, his invention was too far ahead of the times, as his attempts to develop and market the machine failed. After his death, his widow made many efforts to carry on his invention, but she would also have no success. Others would carry on Somerset's work, however, in the later 17th and early 18th centuries.

In 1685, Sir Samuel Morland published a manuscript with a table of cylinder dimensions and how much weight could be raised six inches, 1800 times an hour. Morland's calculations of steam's expansive properties were the most precise of the time. He would not make much more advancement, however; he died in 1696. In 1712, the advancements of the 17th century would bring about the Newcomen Steam Engine, which was the first commercially successful steam engine to be used in Europe. The Newcomen engine would be used to pump water out of mine shafts – essential to the mining process.

Another piece of technology which started in the 17th century was the coking process. Coke is a purified form of coal and was used in metallurgic applications to make pig iron and steel. Up until the 17th century, wood and coal were the primary sources of fuel, but with heavy deforestation continuing in Europe and coal's noxious fumes, a new type of fuel was needed. In 1603, Sir Henry Platt suggested that coal might be charred the same way that wood is charred to form charcoal. In 1642, coke was first used as a fuel to roast malt for beer in Derbyshire. This paved the way for coke fuel, which in the next century would be used chiefly in blast furnaces to produce iron. Coke-produced iron was cheap and would be used heavily during the coming Industrial Revolution.

The topics discussed up to this point were only a few of the advancements made in the 17th century. New discoveries and scientific marvels that would change the world would be accomplished in this century as well.

Scientific Breakthroughs and Discoveries in the 17th Century

The 17th century brought many scientific achievements in Europe in the areas of astronomy, physics, mathematics, chemistry, medicine, and instrumentation. Although some of these experiments were never totally completed, they would still usher in a new way of thinking about our world and how to best learn from it. Many of these accomplishments are not necessarily inventions, but scientific laws and theories, that helped reshape the world into the way we see it today.

In the 17th century, astronomy was progressing by leaps and bounds. New and

exciting theories and planets were being discovered. Leaders in this field included Newton, Kepler, and Galileo.

Since the 2nd century, the prevailing theory in astronomy was the Ptolemaic system, which stated that Earth lay at the center of the galaxy and that the sun, and stars, and planets all revolved around it. In the 15th century, this theory was contested by Polish astronomer Nicolaus Copernicus (1473-1543), who postulated heliocentrism. Heliocentrism states that the sun is at the center of our solar system and that the Earth and other planets revolve around it. This theory solved many problems astronomers were having with the Ptolemaic system, mainly with tracking planetary motion. This theory also had its problems because Copernicus used circular paths, but this would be solved in the 17th century.

German astronomer Johannes Kepler (1571-1630), solved most problems with Copernicus' heliocentric system by claiming that planets and other astronomical bodies moved in elliptical orbits rather than circular ones. This idea would later be clarified by Isaac Newton's laws of motion. Inertia kept planets moving in a straight line, but at some point, they would be pulled back by the sun. The combination of the sun's gravity and the planets' own inertia created an elliptical path. Kepler's theory also solved the problem of retrograde motion.

Isaac Newton (1643-1727), arguably one of the most notable scientists and mathematicians in history, introduced some of his most famous ideas in the 17th century, some of them being his laws of motion. Newton's first law stated that a body in motion stayed in motion until acted upon by a force and a body at rest stayed at rest until acted upon by a force. His second law is fundamental in classical mechanics; it states that the

sum of forces acting on a system is equal to the system's mass multiplied by its acceleration. Newton's third law states that for every action, there is an equal and opposite reaction.

Although not widely accepted in the 17th century by most physicists, electricity was evolving from little shocks cause by static, to actual an actual light source. Electricity had not progressed much farther than static charges during the 17th century, until in 1672, when German scientist, Otto von Guericke, found that electric force generated on metal spheres could cause the surface of a sulfur-coated sphere to glow. Guericke had created the world's first generator.

The 17th century was an exciting time for mathematicians. In 1637, René Descartes published his work *Discourse on Method*, which was mostly on his views of philosophy and scientific reasoning. One of the appendices, named *La Geometrie*, gave an in-depth look into the developing world of analytical geometry. Through analytical geometry, one could solve geometric problems through expressions and equations. Along with fellow scholar, Pierre de Fermat, Descartes blazed a trail through analytical geometry, even to the point of finding maximums and minimums of an equation. Their work paved the way for mathematicians who were concurrently working on a revolutionary type of mathematics known as calculus.

Although many scientist and mathematicians since Euclid (c. 300 B.C.E.) can be credited in discovering and developing calculus, Isaac Newton and Gottfied Leibniz are given the most credit. In 1687, Newton published *Principia*, in which he formally introduced his discoveries and progression in calculus. Calculus has too branches, integral and differential, which are both used widely by engineers, mathematicians,

biologists, chemists and a wide variety of other scientists.

In the area of chemistry, atomic theory was a hot topic. Atoms, their existence, and their properties had been debated since 460 B.C.E. In the 17th century, Pierre Gassendi would consider atoms to not simply be theoretical mathematical points, as many Greek philosophers had perceived. He believed that atoms had definite weight, dimensions, and shapes. Gassendi also believed that when atoms interacted, they could form larger grouping called molecules. His ideas would go mostly unrecognized until the 19th century. Today, his work is taught as part of the foundation for chemistry.

Advancements in combustion theory were also being made. Earlier work with combustion hypothesized that material was in fact dissipating during combustion, because of the fumes seen with the naked eye. Later on, this would be proved incorrect because blacksmiths were finding increased weights after combustion. This increase in weight was known as calcination. Up until the 17th century, it was believed that some element in the fire was causing calcination, when in fact it was caused by the bonding of air with the material. Notable scientists Robert Boyle and Robert Hooke experimented with combustion in water vacuums, but unfortunately, Boyle's oversights in experimentation would hinder Hooke's work on the subject. English physician John Mayow (1640-1679) discovered the nature of oxidizing agents through use of saltpeter, a substance now used in rocket propellant. Although combustion theory would not take flight until the next century, Hooke, Boyle, and Mayow aided in the foundation for later experiments and proved ancient theories incorrect.

In 1665, the medical and biological world would be revolutionized with Robert Hooke's publication of *Micrographia*. In this work, Hooke describes what would be the

first observations of cells in living things. Hooke discovered small "compartment-like" structures in dead cork. He would name these cells because they resembled the living quarters of monasteries. In 1677, Anton van Leeuwenhoek would discover living cells in the form of spermatozoa. He correctly theorized that these cells were used in animal reproduction. Van Leeuwenhoek was also the first to detect red blood cells moving through a circulatory system. In 1675, van Leeuwenhoek discovered one-celled organisms living in pond water. These self-sufficient organisms would be termed protozoa. The work of Hooke and van Leeuwenhoek brought forth entirely new branches of science, which revolutionized the medical field.

The medical field received another shot in the arm in 1628 with the publication of William Harvey's *On the Movement of the Heart and Blood in Animals*. Harvey introduced his findings from experiments on blood flow through the veins and the function of the heart. His experiment proved that the heart pumped more blood than it could contain, therefore it must be receiving blood as well as pumping it. This refuted the earlier belief that blood was absorbed by muscle tissue. His work opened doors for numerous advances in human physiology.

No quantitative results could be achieved without instrumentation. In the 17th century, new measuring devices were vital to scientific progress throughout the century.

The thermometer and barometer were two of the most important instruments developed during the 17th century. The first documented thermometer was designed and built by Galileo in 1610. It used wine in an inverted tube, partially submerged in a basin, which would increase in volume when temperature increased. Galileo's thermometer was very crude and inaccurate however, since wine was a poor choice of liquid and since

the tube was susceptible to atmospheric changes in pressure. In 1641, the Italian Grand Duke Ferdinand II created an alcohol thermometer, which used a closed tube with a reservoir and made much more accurate measurements than Galileo's thermometer.

A barometer measures atmospheric pressure, which could be used in nearly every hydrodynamic and hydrostatic application. In 1644 Evangelista Torricelli, a former student of Galileo, created a device similar to Galileo's thermometer, using a tube of mercury overturned in a basin that increased the volume of mercury in the tube when atmospheric pressure increased. This was the first barometer, and the simple technology used in the 17th century is still used today in many applications.

No instrument developed in the 17th century was more revolutionary than Galileo's telescope. Invented in 1608, the refracting telescope, credited to the Dutch eyeglass manufacturer, Hans Lippershey, used light refraction through a convex lens to enhance images. Lippershay's device gave Galileo a starting point from which to work. Galileo was uninterested in the internal workings of the telescope; he was more focused on its potential application as a window to the heavens. Galileo refined the telescope and began to make observations of the Milky Way. He discovered new seas of stars and celestial objects, like the moons of Jupiter. "In a period of less than a decade from the time it was first invented, the telescope had provided evidence that challenged theories of the universe that had persisted for over 2,000 years," (Windelspecht, 227). Later in the century, long telescopes would be developed, which would improve the focusing of the images to make them clearer and sharper. Long telescopes would also be refined into reflecting telescopes, which were sharper, clearer, and more compact than long telescopes.

These advancements changed the world and gave a strong scientific significance to the 17th century.

Metallurgy

Metallurgy is the process of extracting metal from the ground and making useful objects for mankind. The metal industry was possibly one of the most important pieces of 17th century technology. Through the mining, purifying and shaping of metals, tools, weapons, and armor were constructed. Mining was the process of extracting ore from the ground. The purification phase involved the separation of metal from ore. Finally, there was the shaping stage, which formed, metal into useful objects.

Mining

The first process in this industry was the extraction of metallic ore from the earth. Ore is a mixture of metal or minerals and rock. Hot metal more towards the center of the earth fuses with rock as it is forced to the surface by internal pressures. When ore is found, metal must be extracted from the rock in order to be useful. These processes will be discussed later on.

The most common ways to obtain ore were through panning water sources and shaft-tunnel digging. Panning was used earlier because of its ease and safety, but did not produce much profit compared to shaft-tunnel digging. Shaft-tunnel digging was a much more involved and dangerous process, but its high yield made it worth the risks to many men. Panning was still used, however, in certain places.

Panning was the process of using a pan with holes to sift the sand and sediment from water sources, most often rivers. The moving water would cause erosion of the earth, which would make metallic ore surface. The water would then begin to wear away at ore causing metal fragments to be swept along with the current of the water. The fragments would become more granular as they traveled because of the constant polishing caused by the current. Fragments would mix with soil and sand, which would be then drifted by the pan. The metallic fragments would stay in the pan because of their weight, while the sand would be sifted out. This process often did not produce much metal and its requirement of a moving water source made it less useful.

Although much more dangerous than panning, shaft-tunnel digging would be used much more. There were optimal landscapes in which to dig. Valleys and plains were avoided because of the lack of drainage for water and because of a lack of timber. Timber would be used to make supports for the shafts and tunnels. If there were a river nearby that was downstream of a forest, the river would be used to float logs down to the mine. This would be better than nothing at all in a plain or valley, but would not solve the drainage problem. Manual and water wheel driven water pumps were used to drain out the mines and would become more widely used once steam power was applied in the 18th century. The most optimal location for digging was, "mountainous, gently sloping, wooded, healthy, safe, and not far distant from a river or stream by means of which [one] may convey his mining products to be washed and smelted,"[1] Even though there were optimal locations for shafts and tunnels, digging location truly depended on the ore location.

Because metal flowed up to the surface as it fused with rock and earth, it was

often found in streams, which were called veins. Finding veins was a science on its own and could be considered one of the most difficult parts of the mining industry. Sometimes, veins would become unearthed through natural causes like erosion by wind or water, but most often they were underground. Miners had many ways to find underground veins, but most revolved around using water.

If natural springs were found, one could taste the water and determine by taste what minerals or metals were in the area. Taste tests were used to find salt, aluminum, nitrous, sulfur and other metals and minerals. Panning was used to indicate locations of veins. If a stream contained granular and polished metallic fragments, a vein was far off. As one traveled closer to the vein, fragments would be more jagged and more fixed within earth because the water had not yet eroded them.

During the early spring and fall months, like April, May, and September, one could determine the location of veins through the observation of ground frost. The presence of metal in the soil would slow down the freezing process of water in the ground and plants. So when frost appeared on the ground and on the leaves of plants, a vein would be indicated by wet leaves and moist ground. Metallic soil and water would cause trees to have a blacker bark and leaves with a bluish tint. Finding the vein was only one part of the process, however.

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[1] Agricola, p. 33.

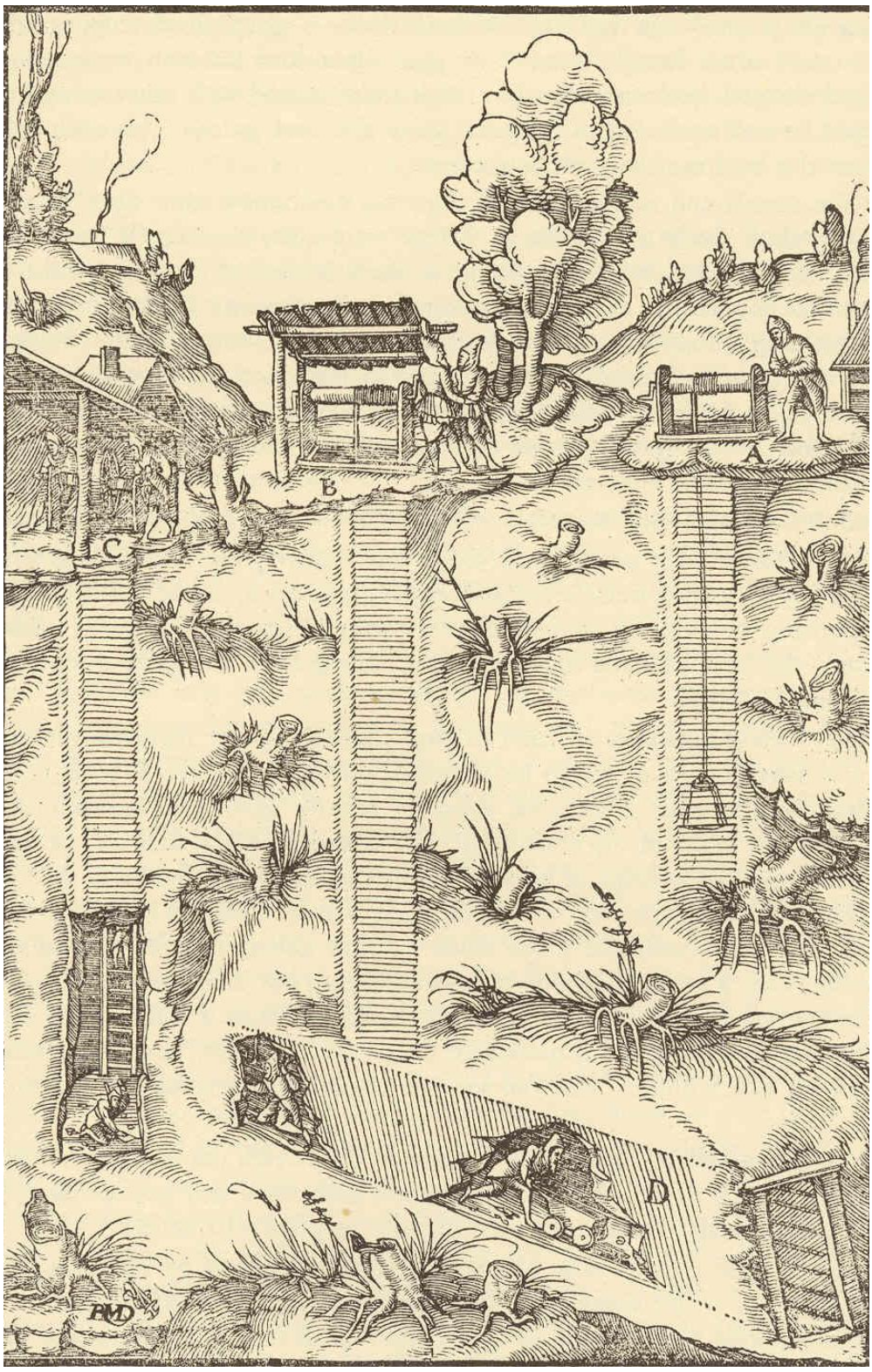

Figure 1: The Process of Creating a Mine Shaft

When a fissure vein (*vena profunda*) or sheeted vein (*vena dilitata)* was found, the miner would start by digging a shaft to reach the vein. A *vena profunda* was a wide stream of ore whereas a *vena dilitata* was a flatter, wider deposit. A windlass, which is a cranking device used to raise and lower buckets, would be build over the opening and a roof in order to protect it from rain.

A typical shaft was approximately two-thirds of a fathom (4 feet) by two fathoms (12 feet) by thirteen fathoms (78 feet). The shaft was used by the foreman to examine the veins and *stringers* that crossed it. Stringers are smaller and thinner veins of ore than fiber out from the main vein. The foreman would examine the way the veins cut through to determine where the most ore was. The geometry and angles of the veins would determine their course and the characteristics of the ore itself would determine where it was coming from and hence where the most was. When the course of the vein was calculated, tunnels would be dug in order to get the most ore out of the excavation. Some tunnels would remain totally underground, while some found their way to the surface.

If a shaft was dug into a hill or mountain, a tunnel would be dug into the side and meet it. A tunnel was dug in order to carry ore out of the mine more rapidly through carts and on foot. Open tunnels also provided better drainage and more light into the mine. A typical tunnel opening was one and one-fourth fathoms (7.5 feet) by three and three-quarter feet.

Veins had their own anatomy, and each was carefully studied to determine its path and strength. Every vein had a source or beginning (*origo*) and an end (*finis*). Veins also had a head (*caput*), which was the top of the vein and a tail (*cauda*) which was the bottom of it. *Venae dilitatae* would use the head and tail more often that the *venae*

profunda, mainly because of nature of it being a sheet of ore, usually vertical.

Ore would typically be dug out with a pick. If a vein went through harder rock, then iron tools would be used to try and dig through it. Fire was also used to heat up the rock and soften it. This would be a slow process; however, since the fire would only soften the surface of a wall of hard rock. Fire also required lots of air to burn, therefore an open tunnel was optimal, but air was still stagnant, therefore bellows would often be used to pump in air.

Pure forms of metals were sometimes found. Gold, silver, copper, and quicksilver were the most commonly found pure metals. Iron and bismuth were occasionally found pure; and very rarely, tin and lead could be dug in pure form. The most common form of metal to be dug out of a mine was ore, which would have to be separated from the rock with which it was fused.

Assaying and Separation

Assaying was an important part of the metallurgic process. Assaying was a process that determined the concentration of pure metal within a sample of ore. Through assaying, metallurgists would determine if it was worthwhile to separate pure metal from the rock for a large quantity of ore taken from a part of a mine. Assaying was basically separation on a smaller and simpler scale, and used quantitative data to determine the ore's composition. Separation involved the repetition of assaying processes to achieve a pure result. Assayers were aware of the quantitative properties of ores and the chemical reactions applied to them, but they could not use this data to its full potential because they neglected air's presence in their reaction formulas.

Assayers used *smelting*, a technique involving the melting or fusing of ore in a furnace, to separate elements. The process of smelting started with fusing the ore to a reducing agent, like carbon (such as coke or charcoal), in a furnace. The heating of the elements would fuse them together and make them react. This would change the oxidation state of the ore and because the agent was a limiting reagent, the agent would be entirely reacted with impurities in the ore. The solution would then be filtered out and the process would repeat, often with several hours of burning or roasting in between to allow the element to softer and break down further, producing purer metals. An example was using coke smelted to iron ore. The oxygen in the ore would react with the coke to form carbon dioxide, which would ventilate out of the furnace.

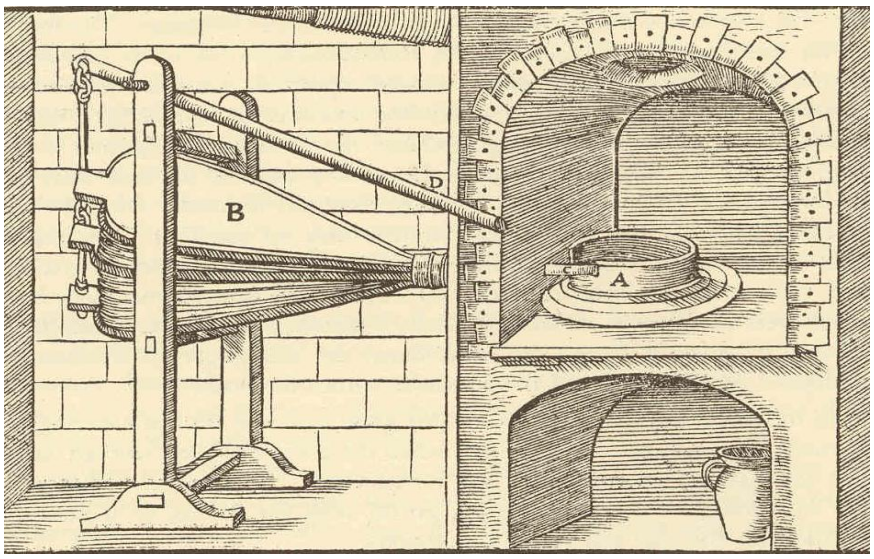

Figure 2: An Assaying Furnace with Crucible and Double Bellows

Fluxes were used to allow for more accurate assaying and better smelting. A flux was a basic compound, often in a cake-like textured form, which would lower the melting point of the elements within the ore. Fluxes, like limestone, were also used to break down the rock within the ore. An assayer could tell what kind of flux was needed based upon the color of the fumes emanating from the furnace. A purple tint was optimal because it meant that no flux was necessary. A blue tint required pyrite or cupriferous rock; a yellow tint needed litharge

and sulfur; a red tint called for glass shavings and salt; etc.

Assaying processes were basically combinations of roasting, burning, crushing, and washing. Assaying furnaces were used to heat the ores. These furnaces could be made of brick, which was easier to work with and therefore quicker to build, or clay and iron, which made them more mobile and durable. For these reasons, clay and iron furnaces were most often used. Charcoal would be burned on an iron plate with holes in it, which would allow air to pass through. A two-chambered bellows was used to fuel air to the fire. As one chamber expanded, the other would contract and vice-versa, thereby always providing a steady flow of air to the flame. Ore that was rich in pure metal was not burned or crushed or washed. It would immediately be roasted in an enclosed *cupel* to prevent metal loss.

Assayers made vessels to hold the ore and molten metal that was placed in the furnace. These vessels were called cupels and were most often made from the washing, mixing, and hardening of ashes from the skulls and bones of animals. The ash compound would allow a cupel to be able to withstand high temperatures in the furnace. Cupels were most often either *crucibles* or *scorifiers*. A crucible was a basic cup-style vessel and was used most often by the assayer. A scorifier was wider and shallower and used more often in smelting or when fluxes were mixed with an ore.

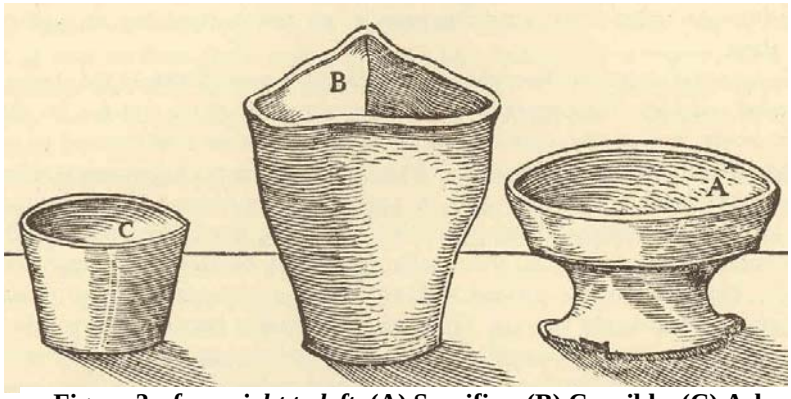

Figure 3: ***from right to left:*** **(A) Scorifier, (B) Crucible, (C) Ash Cupel**

An important development in metallurgy was the blast furnace. Earlier furnaces used a single heat source to start the smelting process, but the reaction would happen mainly on the surface. Through a blast furnace, ore, and agents (iron ore, limestone, and charcoal, for instance) would be poured in through the top of the cauldron-like furnace. Hot air would then be blown into the middle of the furnace by bellows, causing reaction in the middle of the mixture. Slag, the molten impurities formed by the reaction, would then sink to the bottom and be poured out through a spout, leaving the desired element. Although charcoal fired most blast furnaces in the 17th century, in 1709, Abraham Darby would develop a blast furnace capable of being fired by coke instead of charcoal. Because of heavy deforestation in Europe, this was resourcefully advantageous and cheaper, overall.

Many assayers adhered to an earlier form, which did not even require a furnace. A *touchstone*, made from quartz, jasper, or slate, was a slightly rough, black stone, which would be rubbed with a sample. The streak the sample left on the touchstone would then be treated with acid and its color compared with *touch needles*.

A set of touch needles would be comprised of 24 needles, each containing a certain ratio of composition. The most common were sets involving gold, silver, and copper. The first needle would have one part gold to 23 parts silver and the set would continue in succession until reaching the 24th needle, which was pure gold. This form of assaying has also been used in testing the validity of coins throughout history.

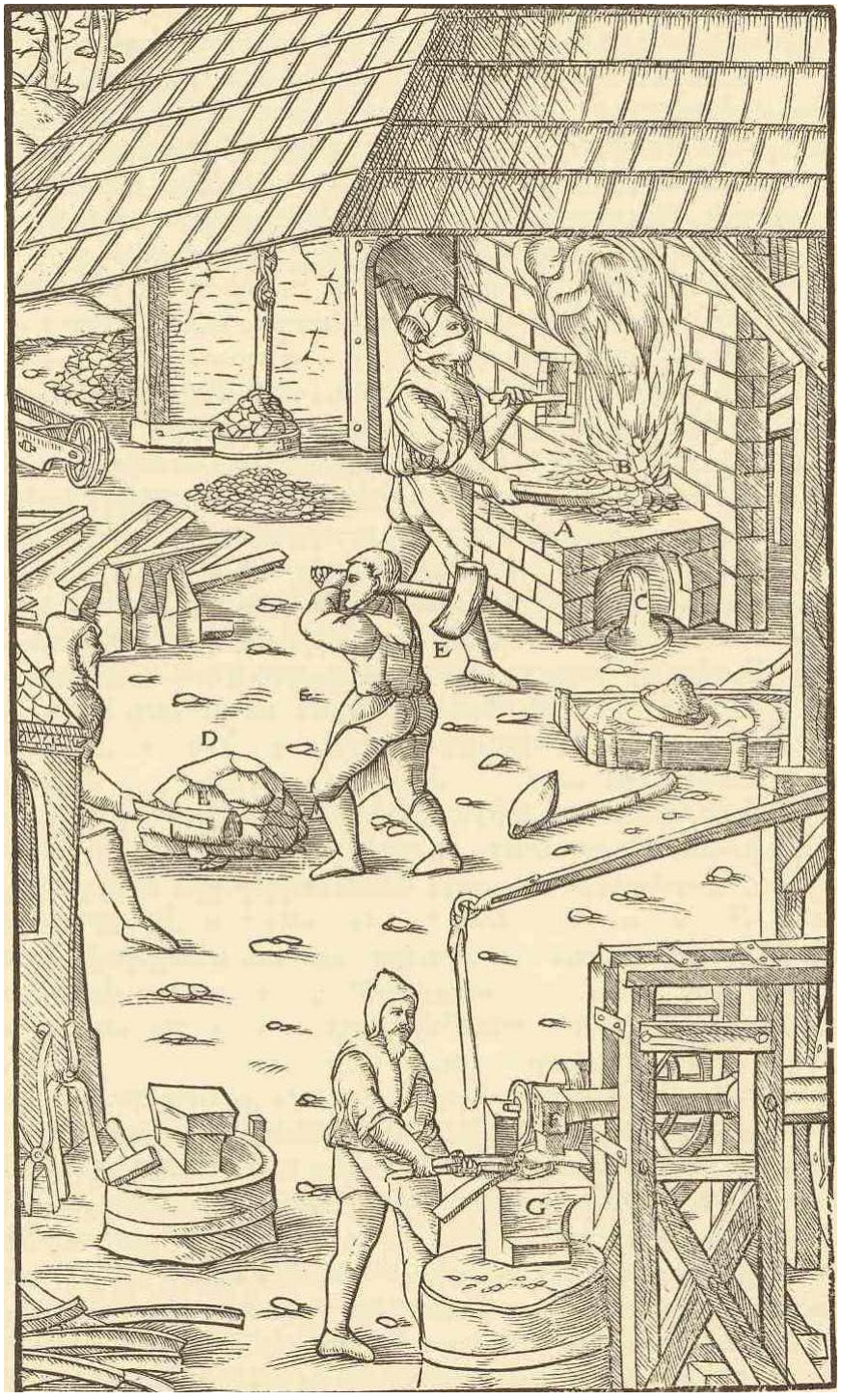

Figure 4: A Blast Furnace and an Iron Mass Being Beaten and then Hammered into Strips

Metal Shaping

Separated metal is of no use unless it can be shaped into useful objects. There were many ways to shape and give form to metal available in the 17th century, but since the century was mostly limited to manual labor and waterpower, no large scale forming would come into the picture until the application of the steam engine.

Casting is one of the oldest forms of metal shaping. A mold, usually made from bronze, would have liquid metal poured into it. The metal would harden and the mold would be broken open, leaving the now solid metal object. A particular form of casting in this century was *investment casting* or the *lost wax method*, in which a wax model of the desired object (called an *investment*) would be made and surrounded by a plaster-like compound. The compound would harden and then be heated until the wax melted, leaving the imprinted shape in the mold. Advantages to investment casting were that using a wax model gave more detail and accuracy to the finished product. Investment casting could also allow for more complex shapes for metals with high melting points.

Forging is also one of the oldest forms of shaping metal. Commonly seen in blacksmith shops, forging involved the heating of metal and subsequent pounding of it with a hammer on an anvil. The pounding on the soft ingot would slowly give it shape. Once completed, the ingot would be hardened and cooled by quenching.

Rolling is a type of process that involves ingots being passed in between a set of rollers spinning in the opposite directions. The result was a thinner, but expanded piece of metal. This process would be repeated until a desired thickness and flatness was achieved. Plates and wire were made from rolling, but unfortunately, the process was limited because of the use of waterpower to turn the rollers. The 18th century would see

steam powered rolling machines with grooved rollers, which could make rods, bars, and rails.

Finally, there was *drawing*, which was used in wire and tube making. Hot metal would be forced though holes drilled into an iron plate. The soft metal was pulled through and cooled. A major disadvantage was that a hole would often close up from the metal rubbing against it. These holes would then have to be repunched. This process was also held back due to the limited drawing power of manual labor.

Metallurgy underwent marvelous change through the use of coke. Coke produced metals were cheaper and cleaner. The manufacturing process would be improved in the next century through the application of steam power. Better-powered technology would allow for mass production and a more versatile metal working industry. Advancements in chemistry and material processing would also aid in the understanding of chemical reactions and make for better fluxes and separating techniques.

Industry and Production

The 17th century was the age of change for modes of production in Europe. Although the process was a gradual one, the 17th century brought a progressive transformation in the way laborers operated and even where they lived. Although industrialists ruled the production piece of the economy in the past, capitalists began to have a bigger role in the decision process. This would eventually lead to the change in Europe from feudalism to capitalism.

At this stage, guilds were still used in most cities and towns. Leaders of nations,

like the French monarchs and German princes, still supported the guilds because they were a source of tax revenue and a way to regulate the economy. Guilds began to change, however, through bargaining with wealthy landowners and others of wealth and power. These capitalists would invest in the guilds' work and collectively form companies. The British East India Company (1600) and the Dutch East India Company (1602) are perhaps the most famous examples. With this new influx of mercantilistic ideals, companies grew into large firms, breaking grounds for capitalism.

Prior to this time period, industry had been run in the cities. Due to the revamping of the agrarian economy, out of work farmers and artisans became laborers and many moved to the cities to look for work. Industry was changing however; it would not remain static. The dynamics of industry encouraged innovations to drive the market and demand for new and better products, chiefly for simple metallic objects such as buttons, nails, axes, and small firearms. Capitalists would find an answer for this demand.

Capitalists had now taken a firm grasp of the reins. Industrialists had concentrated on making money through technological change. Capitalists had merely supplied the forefront cash to do so. Investors had been watching, however, and began making changes in the way companies were run. An important trend seen in the 17th century was the choice to hire labor in rural areas. Rural workers were often just as skilled as an urban worker was (since the latter evolved from the prior), but more importantly, they were cheaper. This cheaper labor allowed for more laborers within company budgets, which increased production to meet demands. This trend would lead to a shift in industry from medieval centers of production to new areas like Buckingham,

Ulster, Westphalia, and Flanders.

The business of iron production was a perfect example of the adaptation of industry to the market. Iron production had become somewhat centralized like agriculture in the 16th century. Although rural by nature, cities like Milan and Liège had become strong points in metallurgy. The demand for more output caused companies to begin moving out of cities and towards rural areas where they could find cheaper labor. New towns would be started around these newly settled companies.

The major change in economic thought in the 17th century was attributed to the continuing evolution from feudalism to capitalism. Although it could be argued that absolute feudalism had not existed since the 14th century, it could also be argued that capitalism did not take full effect until the 19th century. Therefore the period in between could simply be the changeover from one to the other. In the 17th century, the main mode of production was through the putting-out system. Mainly used in the textile industry, companies would hire labor in rural areas to work on pieces of complete products. Often workers would work right out of their homes. The workers would then bring their pieces to central locations where they would be assembled into a compete product and then shipped to the customer nation. Through this mode of production and the use of laborers who do not control it, one can see the beginnings of a proletarian class.

The Dutch were the principal producers of Europe in 1600. They dominated the textile and shipping industries – the most important industries in Europe at that time. Trade revolved around the Dutch. Dutch-built ships dominated the seas, no matter whose flag rode atop them and many countries depended on them to support their own economies. Sweden, for example, dominated the copper, tar, and high-quality iron

industries at the time. They depended on the Dutch heavily for exporting because the Dutch needed such materials to manufacture their own products for export.

At this point in history, we begin to see the economics of Europe coming to the center stage. Every nation with a sea route to the East had its own company that monopolized its country. Indeed even wars were fought by these companies for economic control in particular commodities. Capitalism was beginning to take shape, through centralization and mercantilism. Although not to be officially seen for some time, some were already beginning to form resentment towards capitalism. The proletariat was already being formed and challenging the bureaucracy of the new firms. Socialism's origins are born out of the changes brought about in this century.

Life of a Professional in the 17th Century

In the first half of the 17th century, England suffered severe inflation. Between 1570 and 1639, the price of barley increased by 160% and the price of wheat by 186%. Wages did not receive such a grand increase, however. The median daily wages of a carpenter in 1560 was 12d (pence); in 1630 it was 12d–20d. Laborers, who were paid 8d in 1560, received only 10d–14d in 1630.[2] At the Measham Pits in Leicestershire, c. 1660, an average underground worker made 6 schillings a week. Earnings per ell (45 inches) for heading and sinking shafts were 2/6 (2 schillings, 6 pence) and 6 schillings, respectively. Bonuses would be given for helping with draining or drawing. Supervisors earned 6 schillings a week, while sharpeners, watermen, woodsmen and horsekeepers each earned 5 schillings a week. The blacksmith sometimes earned up to 7 schillings a

week.[3]

The majority of professionals, businessmen, and officers in the Royal Army and Navy in late 17th century England made £50-£125 per year.[4] The majority of the gentry made between £126 and £250 annually. In the cities, unity was kept up in appearances; guilds worked together, festivals were had, and holiday plays were seen. These communal showings continued until the mid-seventeenth century. With the decline of urban life and more migration towards rural areas, these customs ceased. The social system of England had always been apparent. Gentry often received better seating in church and social settings and better quality goods and services. Through the communal gatherings, this system had not been so dreary. Commoners were assuaged by the false pretense of community life and celebration. At the core of city life was social inequality and poverty because of inflation. Cost of living standards had increased, while wages did not. Although the over half of the professional class made less than the gentry, the rest made as much, and in some brackets more than the gentry did. Lifestyle truly depended on the company one worked for and how skilled one was.

Siege Technology

For as long as cities have stood, sieges have been laid. A siege is a military tactic, which basically involves breaking through physical barriers protecting a city or castle. Sieges often took months or even years and were basically a mini-war of attrition, whoever's army and supplies held out the longest would usually win by a surrender of the

[2] Fisher, p 164-165.
[3] Bullock.

enemy. Siege warfare has been used throughout history, from the walls of Jericho to the present day siege in Fallujah. For such an old military tactic, one might think that eventually, it would evolve to its fullest and become disregarded; but as one can see, for as long as something is defended, attempts to penetrate those defenses will occur.

A major part of siege artillery was the cannon. Cannons had been used in European warfare as early as the 14th century. Cannons were usually cast out of bronze or iron and were categorized by the weight of the shot they could handle. Cannons replaced earlier trebuchets and catapults and would be followed in the 18th century by Howitzers and mortars.

In order to cast a cannon barrel, a mould first had to be created. The mould started with a copy of the actual sized barrel needed, called the *pattern*. The pattern was often a long wooden shaft wrapped with heavy rope and the covered with clay. It was baked until hard and then covered with wax. Wax was also added onto the pattern to make more detailed pieces. The pattern was then pressed into soft clay and covered heavily with it, then baked. The wax coverings would melt and flow out though pre-made holes in the mould, leaving the pattern, and imprinted design within. The mould would be split and the pattern removed. Any imperfections in the mould would be fixed and then redried.

The mould needed a core imbedded to give the cannon a chamber within the barrel. The core was made of an iron rod smaller than the required diameter. It was plastered with a mixture of clay, horsehair, and manure and then turned against a template for smoothness. The rod was centered within the mold using centering rings with three mandrills forming a three-pointed star.

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[4] Grassby.

The mould was now ready for casting. It was placed within the casting pit and packed tightly on all sides by sand for extra pressure. The furnace was kept close to the pits so that the molten metal would flow more smoothly into the mould. After cooling down, the mould was split and the imperfections worked out of the barrel. The core was removed and was set for drilling. Huge drills bore out the inside of the barrel. The successive bores were generally done to get the finished inner diameter. Later on in the 17th century, cores would stop being used and boring out solid casting was done.

After completion, the cannon would be sent for test firing. Powder charges were used and were often heavier than actual field shots. The barrel could fail and split for a variety of reasons. If the metal was too hot during casting, elements which added elasticity would be burnt up. This would cause the barrel to be too brittle and split under the pressure of the shot. If the metal was not hot enough, then air pockets would form in the cast and allow for weak points once cooled. If the powder charge used was too strong, then the muzzle, or open, forward end of the barrel, would split due to the in rush of air after the shot had exited the cannon. The cannon would also fail if the core had been misaligned prior to casting. A misaligned core would give an uneven distribution of metal and force thinner walls to fail under the pressure. If the cannon passed the test firing stage, it was sent to the carriage maker, to be given a suitable carriage so that it may be brought into battle.

Siege fortifications made marvelous advancements in the 17th century. Advancements made in the 17th century still kept the basic walls, towers and moats, however, application of tactics aided in the evolution of the fortification. In the 17th century Italian engineers designed a new style of fortification using a star shaped layout.

The angled edges of the layout made direct hits very difficult. With deflected shots, *ramparts*, which were the walls of the fortification, withstood the siege longer. These new fortifications could also hold many more men, increasing the chances of winning the siege. Italian designs were spread throughout Europe during the 16th and 17th centuries, but the problem with these new layouts were that they were often very expensive and could render a country crippled with a downsized army due to overspending on defense. The Dutch built fortresses which followed Italian guidelines, but were simpler and cheaper to build. The most important parts of neo-Italian fortifications were their angled wall and sharp corner designs.

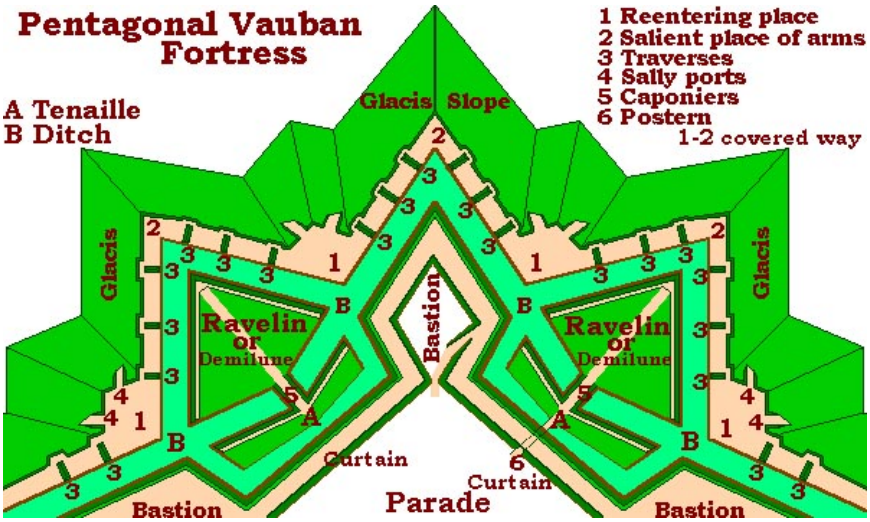

Figure 5: A Pentagonal Vauban Fortress

Angled walls to protect against direct hits were only the beginning step into thinking like the enemy. In the late 17th century, a French military engineer named Marshal Vauban, perfected siege warfare of that time period. Vauban added trenches, outside the walls, sometimes added half filled with water to further slow down the attacking army. Normally, as attackers made their way to the walls of the city, defenders would lose their lines of sight to fire upon the attackers. In order to solve this problem, Vauban added a *glacis*, which was a mound of earth placed against the wall in the form of an incline. This gave defenders the most time to keep the attackers in sight and be able to fire upon

their enemy. When attackers made it to the straight walls of the city (called the *curtains*), protection would be given not only from the walls themselves, but also from the *bastions*. Bastions were extensions of the tops of the walls at the corners of curtains. Bastions would often be triangular shaped to give two side of protection. From a bastion, defenders would fire upon the enemy from the side as he was trying to scale a curtain. Vauban's main concentration of his defenses was to *enfilade* the attacker. Enfiladed attackers would be constrained by fire and aspects of fortification to attack in a column formation. This type of formation would increase the chances of a defensive direct hit on the enemy. If the enemy was lined up and constrained to stay that way, they could not dodge fire from the front.

Vauban also wrote of the art of besieging a fortress. *Circumvallation trenches* would be dug around the besieging army in order to protect it from the besieged army's attacks. Further out around the circumvallation lines, *contravallation lines* would sometimes be build. These would be constructed of ramparts and towers and would be used should a field army allied with the besieged army attack the besieging army from behind. Trenches, called *saps*, were used within the besieging army's area to connect soldiers to each other. These saps could not be perpendicular to the city's walls because the besiegers would then be enfiladed. Sharp zigzag patterns were used.

Lines containing the main battery of heavy artillery would be made about 600 meters from the walls. Once these lines were set up, lines of smaller cannons would be created about 250 meters from the fortification. The final lines were created about 30 meters from the walls. These lines were used as *staging areas*, areas for assembling troops for ground attacks. Staging lines were usually not constructed until the walls had

been breached.

Entire military campaigns could be run solely within a siege such as the Siege of Ostend from 1601-1604 or the Siege of La Rochelle from 1627-1628. Because so much emphasis was placed on the siege, often they were a slow grinding process. Sides would often be in a stalemate so long, that whichever side endured the longest through wounds, disease, and starvation would usually win. In the next century, during the French Revolution and Napoleonic Wars, advances in artillery would allow sieges to be decided in days or weeks instead of months or years. This would lead to a more open-field combat by armies and put less emphasis on attacking or defending a single fortification.

Technology in many cases came to a pinnacle in the 17th century. Manual labor and water-powered machines would yield to steam engines in the next century. Use of charcoal would become extinct due to the application of coke. Siege fortifications would be refined by Vauban. Cannons would be replaced by Howitzers and mortars. Capitalism would begin to overtake the old feudal ways in the evolution of economics and production.

The 17th century can be defined as a technological time where many branches of science were on the cusp of new and radical developments. By the 18th century, the many of the techniques used in manufacturing, warfare, processing, and industry discussed here, would be rendered obsolete. Technology in the 17th century not only gave the incentive for new invention by reaching its pinnacle, but also gave the means to create new invention. Without advancements made in several areas of technology, like steam power, calculus, chemistry, economics, medicine, and physics, the new inventions of the 18th century would not have occurred.

17th Century Weapons

By Chatura Weliwitigoda

Blade Weapons

Swords

The 17th century was a time where many advances in weaponry were made. Many things changed in warfare but one thing did remain the same, and that was the use of the sword. There were many different types of swords used for different purposes including military, hunting, and social purposes. The sword was an instrument that could inflict pain and death, but it also was an object of art and beauty.

Throughout Europe swords were widely used in the 17th century. Depending on the country and region swords were similar but also different at the same time. For example, a curved sword that was used by the Turks was different from a curved sword used by the Germans, but it was still a curved sword. It is differences like these which made 17th century Europe a "storage room" for different types and styles of swords.

There are several different classifications for swords. Curved swords, long swords, short swords are some of the major classifications. Within these classifications there were plenty of different styles of swords which usually depended on what region on Europe it came from. Some swords were used by different parts of the military. For instance, the cavalry didn't use the same swords as the foot soldiers.

Curved swords were widely used in the military throughout most of Europe. These swords were usually for cavalry use.[5] They were very popular in Eastern Europe where this sword has Islamic origins. The blades on curved swords were single edged and usually had multiple grooves. In countries like Poland and Hungary, the main curved sword was called the Karabela. The Karabela had a grip formed of plaques which were held by rivets to the tang. The guard was usually a cross with short languets. The Karabela was used by the cavalry and the cross-guard extended to form a substantial knuckle-bow, which reflected German influence. The Turks used a curved sword whose hilt had a simple cross-guard with very long extensions that ran up the grip and down the blade. In Northern Europe curved swords had a distinctive pommel, which took the shape of a lion or some other fierce animal. The guard was fitted with perforated plates on each side and the blade was long, slightly curved, single edged and had multiple grooves on the back edge. As the century went on the design was modified to shorter guards with one quillon and a knuckle-bow. Another long-lived curved sword was the falchion. This weapon was quite different from the conventional curved sword. It had a re-curved cross-guard and short heavy cleaver-like blade.[6] It was used by troops, which were in charge of arranging transports and wagons during the Thirty Years War. Italy and Germany had their own version of the falchion. It had a very short broad blade, was single edged with a clipped point. A simple S-shaped bar with down turned quillons was utilized for the guard. The knuckle-bow stopped short of the pommel which had a flat extension on the back.

Figure 6: Karabela

[5] Swords and Hilt Weapons by Michael Coe [Pg 34-35]
[6] Swords and Hilt Weapons by Michael Coe [Pg 35-36]

Another rare curved sword was the dusack, which was made from a single piece of steel which was shaped like a broad, curved single-edged cutlass.

During the 17th century there was another sword that was also used mainly for combat. The saber was a powerful weapon that was widely used in the battlefield. The saber was also used as "attire" by the gentlemen in that era, but its purposes were more for combat rather than show.[7] The Polish saber had a "closed hilt" and was also known as the "hussar's saber." It had a rounded knuckle-guard and it was bent to about one hundred degrees. Some sabers had the knuckle-guard just bent vertically and not joined at the pommel; others had rounded knuckle-guards with horizontal bars to protect more of the hand. There were many different designs for them. The blades of sabers had a circular curvature and the width of the blade and cuts to their opponents with sabers. The Tartar saber was the Polish military saber; it had a blade that was very long and heavy.

Figure 7: Falchion

Figure 8: 17th Century Saber

Besides curved swords, the cavalry had other types of swords in their arsenal of weapons. The backsword was commonly used by the cavalry as a piercing and slashing weapon. Backswords were usually worn by cuirassiers. During the 17th century backswords went through some modification. The

[7] Swords and Hilt Weapons by Michael Coe [Pg 35-36]

pommel took a more globular octagonal shape, which was one of the main designs used in England. The hilt had fully developed arms and the quillons were counter curved. A knuckle-bow and a loop guard were also put in. This design was not only used on backswords, but also on swords such as the English rapier and riding swords also shared the same design.

One of the more commonly used swords in the 17th century was the rapier, which had both military and civilian applications.[8] At first the rapier was a two edged sword which was mainly used for cutting and thrusting. In Northern and other parts of Europe, the rapier was a sword that civilians used to bring with them as regular attire. The civilians usually had a rapier which was just a long, pointed fencing sword. Gentlemen wore rapiers to show signs of rank. The more embellished the sword was, the richer and more noble you were. It was also used for dueling, which was the case when the gentlemen tried to defend their ladies' honor. The rapier blade usually squared-off (ricasso) immediately below the grip.[9] This was done in order to better direct the use of the weapon. The offensive part of the blade usually varied depending on the hilt and the usage. In the latter part of the 17th century the rapier went through some changes in size and form to create a new type of sword; the small sword.[10]

Figure 9: Rapier Hilt

[8] Rapier and Small Sword by A.V.B Norman [Pg 7]
[9] Rapier and Small Sword by A.V.B Norman [Pg 63]
[10] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg 441]

The basic design of the small sword was the same throughout Europe. The Italian small sword had a hilt, which had delicately chiseled scrollwork. In Saxony the hilt was made of steel or guilded bronze, and the grips were made of Meissen porcelain. The Germans had hilts which were brightly colored.[11] The blades for small swords were flattened, hexagonal-sectioned, rhomboid, or triangular-sectioned blades. The small sword originated from the rapier, which is a very interesting change that the weapon went through. The rapier had been used from the late 16th to early 17th century, by the end of the 17th century it was turned into a small sword. The blade of the rapier was shortened and the made broader. This change began happening around the 1630's, which was when small swords or "light rapiers" were considered fashionable to wear. By the 1640's new hilts were developed for small swords. The hilts consisted of a guard which was formed of a large double shell with the blade passing through it. This was one of the final steps in the evolution from rapier to small sword.

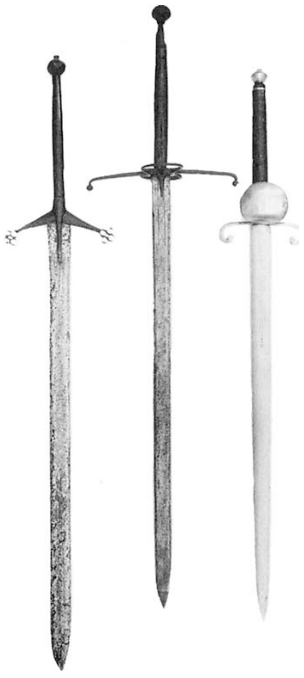

Figure 10: 17th Century Claymores

Another sword used during battle is the claymore. The word claymore comes from the Gaelic word "claidheamohmor," which meant great sword. The claymore was a cross-hilted broad sword. This weapon was used in the highlands of Scotland, by mercenaries during the 17th century. It had a straight, broad, double-edged blade, and it also had long, diamond-sectioned quillons which were angled towards the blade. This blade was shorter than conventional two-handed swords, and was used by foot soldiers in

[11] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg 441]

battle.

Figure 11: Hanger

There were some swords which were used for hunting purposes only. Short swords like hangers were exclusively used for hunting.[12] This weapon was widely carried, especially in England. Some of these swords could have a hilt of iron, with a pommel in the shape of a bird or another animal head. Some hangers also had the re-curved quillons, which had a small shell attached to it. The blades were usually short and curved.

Swords in this period went through changes in many different ways. The hilts of swords were also an important part change that depended on the region in Europe. In the early part of the century Italian designs for sword hilts were cross-hilts with knuckle-guards. This was all around the years of 1600-1640. Western European designs for hilts also incorporated the cross-hilt in the early part of the century, knuckle-guards and knuckle-bows were added for extra protection. Through the mid part of the century Western European designs changed; the cross-hilts were curved at opposite ends, and the knuckle-guards were change to cover more of the hand. The Italian designs changed as well; cross hilts weren't too popular anymore, so a circular guard was placed above the grip, which covered the top part of the hand.

Figure 12: Shell Hilt

Many swords shaped the 17th century, both in the battlefield and in society. Swords were elegant instruments of death that were symbols of power to anyone who owned them. The gentlemen that did have swords as part of their daily attire, probably wanted to benefit from the elegance and power that was present in their sword.

Daggers

Swords weren't the only blade weapons used in the 17th century. Daggers and combat knives were also carried by soldiers as an extra means of protection in the battlefield. There were a number of small blade weapons that a soldier could use. In the early 17th century daggers were usually carried with rapiers. This was discontinued around the year 1640. Nonetheless, daggers were continued to be produced even after this. Some of these daggers included dirks and stilettos, which were more of the standard daggers used at the time. There were some daggers however, that were far from the standard. Other daggers were used as a symbol of prestige and honor by civilians and guards.

The Scottish dirk, which was a descendant of the medieval ballock knife, was one of the earlier daggers produced in the 17th century. The earlier dirks had two lobes which were connected at the junction of the grip and blade. The grips of dirks were usually decorated with bands of studs and interlaced work. The norm by the end of the 17th century was to entirely cover the hilts with interlaced work. The blade of a dirk was usually broad, single edged and sometimes the back edge was set with brass. In the second half of the century, the grip was sometimes done in brass, which was usually

[12] Swords and Hilt Weapons by Michael Coe [Pgs 78-79]

decorated and engraved.

Figure 13: 17th century stilletto

The stiletto is one of the most famous daggers known to us today. It was the best-known Italian dagger; its tapering blade was of triangular section. The quillons were generally short and straight, and the grip was usually narrow and it also had a small pommel.[13] The hilt and grips took many different forms. Wrythen grips were grips and quillons which were pierced and chiseled to represent helmeted warriors. The hilts were usually cut with diamond-shaped facets. Some stilettos were developed for gunners. The blades of these stilettos were usually engraved with a table for calculating the weight of the shot needed for the cannon.[14] Most stilettos were probably developed for self-protection, because most of them were short and plain. The Italian stilettos go back to about the year 1650 and the prototypes for the stilettos go back to the year 1600. The prototypes were thrusting daggers with very long and narrow pommels. More daggers were created for different types of guards.

Figure 14: Main Gauche

Some daggers like the main gauche were intended for the left hand. Main gauches were usually used by right-handed swordsmen, who would carry their sword in their right hand and the dagger in their left. It was the reverse with left-handed swordsmen. The blades of these daggers had a distinctive central ridge, which might be inscribed and dated.

Not all daggers were as straightforward as the ones mentioned above. Some

[13] Swords and Hilt Weapons by Michael Coe [Pgs 81-82]
[14] Swords and Hilt Weapons by Michael Coe [Pgs 81-82]

daggers were put on the guns as an accessory like a bayonet, and others used "trickery" to get to their opponents. There are some daggers with blades which divide into three separate sections at the push of a button. When the button is pushed, it operates a powerful spring which is set in the blade. These daggers were known as dueling daggers had the ability to catch opponent's rapiers and hold them away from the body giving the swordsman an easy target to strike. This dagger was made in the first quarter of the seventeenth century. These daggers mostly originated from France and Italy.

The sword breaker was an English dagger, a quillon dagger which was fitted with a relatively simple guard but had a massive saw-edged blade. The purpose of this dagger was to catch an opponent's sword blade, with the saw-like teeth cut into it. Well-tempered blades could be broken by sword breakers.

Bayonets were daggers which were attached to guns and muskets. The word refers to Bayonne in France, which was an important blade-making center. Musketeers were armed with bayonets. There are two different types of bayonets, a plug bayonet, and a socket bayonet.[15] A plug was bayonet was designed to fit inside the barrel of the gun. It had a tapered grip and the blade was 12 inches. The military versions were usually plain and uninteresting, but after the year 1680, more elaborate versions were made. Some versions were also made for hunting.

Figure 2: Plug Bayonets

The socket bayonet was designed to fit the socket on the side of the barrel of the gun. In Italy and Spain the bayonets were made for the chase, and were usually

decorated. In the year 1688 French troops were also given a bayonet with a sleeve that would fit over the muzzle of the gun.[16] Bayonets were a creative way to combine a relatively new technology like firearms with old-fashioned blade weaponry.

The Saxon Electoral Guard had daggers which had large pommels and were fluted. The blades were plain and the quillons were short. The Dalmatian troops in Venice used a dagger which had a blade with a tapering triangular section. The quillons turned sharply down towards it. Both pommel and were cut in spiral flutes.

The dagger was an important part of a soldier's gear; even though it was small. Daggers went hand-in-hand with swords and played an important role during battle. Though daggers and swords were important during battle, they were not the only weapons that soldiers had to rely on.

Staff Weapons

Staff weapons were used throughout history as a powerful weapon to hold off enemies. From about the year 1200 to 1650 the pole-arm was used once again in the battlefield. Their appearance signified the end of armored horsemen and gave an increased importance to the infantrymen. Most staff weapons were used in the military to show rank. Throughout 17th century Europe, there were many different types of pole-arms. They can be classified by the following uses: thrusting, cutting, percussion, and combination types. Throughout the years pole-arms slowly evolved and took shape to be deadly weapons.

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[15] Swords and Hilt Weapons by Michael Coe[Pg 81]
[16] Swords and Hilt Weapons by Michael Coe[pg 81]

Thrusting pole-arms played an important role in the battlefield. The langue-de-boeuf (ox tongue) was a pole-arm that had a flat or long ribbed blade. The blade either had a square or triangular shape which went to a tapering point. Another weapon that was very similar to the langue-de-boeuf is the early partisan. The early partisan had small wings at the base of the blade, which was triangular in shape, and as time went on these wings got longer and more decorative. It was used as a weapon in earlier centuries but in the 17th century was used by officers to indicate rank, but was also used as weapon when necessary. There were many versions of the partisan. One of the different versions of the partisan was called the corseque[17], which had curved wings bending back towards the butt of the weapon.

Figure 16: Pike Head

One of the more famous thrusting weapons was the pike. The pike was a spear used by heavy infantry. It was used for thrusting more than throwing. It was about 14 to 20 feet long, and usually had a small head. The shafts were protected for 3 to 4 feet to prevent them being cut by swords of the opposing cavalry. The pike was used as a defense from cavalry; it was braced onto the ground and pointed towards the opposing cavalry. The pike men protected the musketeers as they were reloading.

Another thrusting pole-arm that was used by the cavalry was called the lance. It was also called the Horsemen's Spear. This weapon was divided into 4 parts, the truncheon, the shaft, the head, and the grate. This weapon was used to knock more horsemen off their horses.

[17] The Halberd and other European Polearms, George Snook [Pg 15]

Cutting pole-arms were another array of weapons used in the battlefields. They could deliver devastating wounds and could incapacitate an enemy very quickly. The classifications of cutting pole-arms comes from one type of pole-arm called the couteau de breche, which was basically a knife blade attached onto a shaft. This weapon was primarily a slashing and chopping weapon. All other cutting pole-arms evolved from this basic design. Weapons like the glaive, the bardiche, the lochabar, and the Jedburgh axe are examples of pole-arms used in 17th century combat[18]. The glaive was a larger couteau de breche. It had a small extension on the back, which could have been used as a parrying hook. The bardiche was a pole-arm with a long crescent-like blade, which extended far beyond the pole. On the upper end it was attached to the shaft with a socket and on the bottom end it had a flange which was nailed to the pole. This weapon was used to slash enemies and sometimes even used to chop limbs.

Figure 17: 17th Century Halberd

The halberd was one pole-arm that went through five centuries of changes. The halberd is classified as a cutting weapon, although as years went by and advances were made it became a combination type staff, which incorporated thrusting and cutting, but by the 17th century it was the thrusting part of the weapon that was the most important. The halberd consisted of "an axe blade surmounted by a thrusting point backed by a pointed beak."[19] In the 17th century there were many changes made on the halberd. Some of these advances were the following: elaborate

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[18] The Halberd and other European Polearms, George Snook [Pgs 16-17]

[19] The Halberd and other European Polearms, George Snook [Pgs 3-4]

piercing and engravings were put on, the reinforced point was eliminated, and it was given a light square head with a short spike. The halberd was also used to show rank. There were usually used by town militiamen, place, and church guards who carried them as parade weapons.

Axes like the Lochaber axe, had two sockets which attached the blade to the pole. The blade was usually large and curved. There was a hook which faced the opposite edge of the blade. This weapon was used to severely cut the enemy. The use of the hook is still under question. Another axe used around this time period was the Jedburgh axe. They were known as Jedburgh staves in the early 17th century. The axe is from Scottish origin.

Figure 18: Lochaber Axe

Percussion pole-arms consisted of one-handed weapons such as the mace, war hammer, and the bec de corbin. These weapons were designed to be used on horseback.

Figure 19: Morgenstern

Weapons like the military flail and the Morgenstern are prime examples of percussion pole-arms. The Morgenstern was a club which usually had spikes arranged in a "star" configuration. It sometimes also had a spear point at the end. It was used to deliver fatal blows to the enemy; the combination of the force at which the club was striking the opponent and the spikes thrusting through the skin and bone, made this weapon a very dangerous asset. Though these weapons are primitive, some were used in parts of Europe in the battlefield.

Combination pole-arms like the English bill are considered to be another version

of a halberd. The blade of the English bill differs from the blade of the halberd. The blade has a forward curve on the upper end, which also a characteristic of the agricultural version called the billhook. The spear of the weapon was usually round, square, or flat. The Lucerne Hammer was another combination pole-arm had a spear point and a pointed beak. Instead of a blade like the halberd, the Lucerne Hammer had a four-pronged hammer. The prongs were meant for piercing. The weapon was meant to pierce an opponent while delivering a devastating blow to the enemy.[20]

Even though pole-arms were becoming less useful by the end of the 17th century, they served as a deadly weapon in the battlefield. They were always considered a secondary weapon and never got the type of recognition that swords would get; even though, they were important in the battlefield, the use of pole-arms became more and more uncommon when firearms were being used in the battlefields.

Firearms

Firearms in the seventeenth century were an integral part of the battlefield. A relatively new technology for those times, firearms shaped and changed warfare. Even though firearms were invented centuries ago, even today we see the effects of firearms in warfare.

It is important to note that when firearms did come into regular use in the battlefield, some of the older weapons which have been used for hundreds of years were slowly being replaced. For instance, archers were a breed of soldier which coming to an end by the seventeenth century. More and more countries started to rely on the use of the

[20] The Halberd and other European Polearms, George Snook [Pgs 20-21]

firearm than the bow and arrow. It is obvious that the introduction of the firearm to the battlefield was of historic proportions that took place in all of Europe.

Ignition systems and their evolution was one of the most important developments to happen in combat in the 17th century. All the countries in Europe benefited from these advancements. The battlefield was slowly but surely becoming overrun by firearms. The firearms of that time period went through many different changes, in design and ignition systems. The ignition system was one of the most important parts of firearms. There needed to be an efficient ignition system to fire the ammunition. There were different types of ignition systems, which evolved through time. The ignitions were the following: matchlocks sear locks, wheel-locks, and flintlocks.

Matchlocks were ignition systems which incorporated the slow match, which had to be brought into contact with the priming powder. This was done by a combination of levers. When the lower arm is pulled up toward the stock, the upper arm is lowered to the pan. This ignition originated from the trigger mechanisms of crossbows.[21]

There was another type of matchlock called the snap matchlock. This ignition system was attached to a metal plate. It had a cock which was kept pressed onto the pan with the spring. The cock had jaws which held a slow fuse or match. In the lock plate, a stud or sear protruded through an aperture.

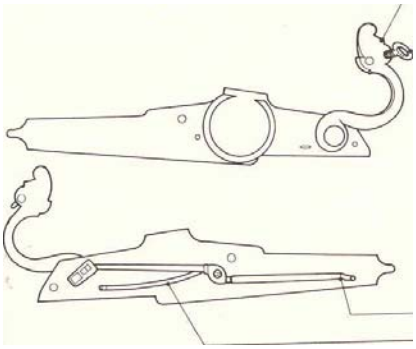

Figure 20: Wheel-Lock

As the cock was raised from the pan, the heel, a section at its lower end, was held by the sear. A button was placed at the rear end of the sprung lever. This button projected through the lock plate. As soon as the button was pressed, the cock was released by the

sear; allowing the cock to snap down onto the pan.[22] This ignition system was rarely used in the 17th century but was found in some guns.

The sear lock was an ignition system which was introduced in the late 16th century and was used till the close of the 17th century.[23] The sear lock was different from the snap-matchlock, because it operated in the opposite fashion. The cock which had the slow match was held back, away from the pan. Linked by levers and to a long lever shaped trigger, the cock was pivoted on a spindle. This trigger was underneath the stock and ran parallel to it. The cock was lowered into the pan when the trigger was pulled towards the stock.

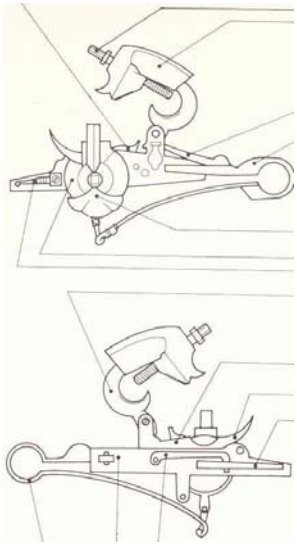

Figure 21: Match-Lock

Another category of ignition systems was called the wheel-lock. This ignition system consisted of a lock plate, which was shaped to fit a wheel. A pan was attached to the top edge, and there was a wheel which was mounted at the bottom of the pan. A strong V-shaped mainspring was linked to a short chain. The short chain was also the wheel spindle. The lock plate was a sear, which was held into position by a spring. The cock could be moved onto or away from the plate manually. The cock was brought down on to the pan cover when the wheel was turned until the sear clicked onto position. Once the sear was engaged, that's when the cock struck the pan and fired the gun. The wheel-lock was not used much during the 17th century because it was replaced by the flintlock.[24]

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[21] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg]
[22] Complete Encyclopedia of Armor and Weapons by Claude Blair[Pg]
[23] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg]
[24] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg]

The flintlock is believed to have been invented in France around the year 1620, by an inventor called Marin le Bourgeoys. By the 1640s the flintlock had already been fitted on military weapons. The flintlock was a type of snap-lock, which had a vertical sear which was attached to the inner side of the cock spindle. Another variation of a flintlock ignition was called the snap-hance lock.[25] The flint was held in the jaws of the cock, which struck the steel plate that was vertically (hinged) over the pan. Scottish firearms incorporated snap-hance locks in their design.

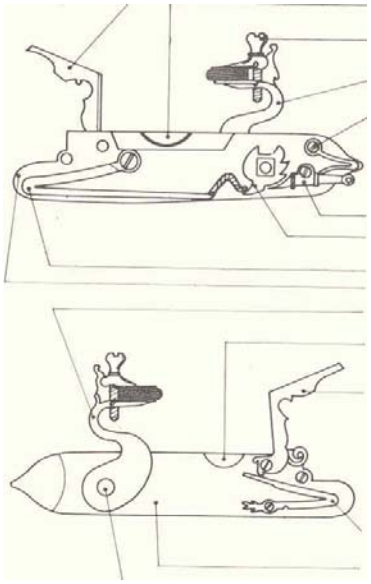

Figure 22: Flint-Lock

With firearms appearing in battle, different and new military strategies were brought about, which changed warfare considerably in those times. Firearms were used in all the countries in Europe. To the public, one of the well-known firearms of that time was the musket. The musket, in combination with other firearms, shaped modern warfare. Firearms, being a relatively new technology, were produced or sought out by every country in Europe during this time. Some of the firearms of that period include the musket, the caliver, the carbine, and the harquebus.

The musket was a weapon that was developed slowly but surely and led to the replacing of archers in the battlefield. Most muskets were quite hefty pieces of equipment and required many other accessories to go with them. A ramrod was one of these accessories which was used to pack the bullet and powder into the barrel of the musket. It was usually a little longer than a barrel of a musket and was made of wood. A

[25] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg]

powder pouch would also be carried by the musketeer; this was to make sure he had an ample supply of powder during battle. A fuse rope was also needed to light the gun powder. The fuse rope was used in the ignition systems of the muskets. Since the musket was large and heavy, usually the musketeer would need a musket rest. A musket rest was a pole that gave the barrel of the musket support while the musketeer was shooting. It usually helped the musketeer control the gun and supported some of the musket's weight.

The harquebus was a light gun, which had a barrel length of 75 cm (2.5 ft), a bore of 17, and a total length of 90 cm (3ft). This was another firearm that was used by the cavalry, but in the 17th century it declined in popularity and it was replaced by the carbine.

The carbine was a firearm that was prominent in battle. It was used by the cavalry. The term describes the firearm as being a short, light gun. Carbines were said to be "about a yard or more long in the barrel." The carbine was usually fitted with a wheel or snap lock. It contained a side bar so it could be carried around the shoulder. They had a barrel of 76 cm (30 in), a total length of 114 cm (44 in), and a bore of 24.[26]

The caliver was a gun that was longer than harquebus but shorter than musket. It was a term that was used in England to describe "a type of long gun used without a rest for military purposes."[27] The barrel length of a caliver was about 100 cm (39 in), a bore of 17 and its total length was about 137 cm (4.5 ft). This fire-arm was not used in England after the Civil War.

Pistols were secondary weapons used in the 17th century battlefield. The barrel

[26] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg 113]
[27] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg 111]

length varied upon country. Some barrels were longer than others, but the average barrel length was about 8.75 inches, and the average total length was about 14.5 inches and they weighed roughly around 1-4 pounds. Though pistols were used in the military; it wasn't uncommon for civilians to also own pistols, which were used for various reasons.

Some firearms weren't as "straightforward" as the ones mentioned above. During the 17th century there were some guns that were known to have more than one barrel. Some pistols were known to have as many as 9 barrels. Other firearms also had rotating barrels, which could be called the early versions of machine guns.

Figure 23: 17th Century Gun with 9 barrels

Firearms slowly started replacing weapons that had been used for centuries. Firearms like the musket slowly but surely started to replace the pike. Once the bayonet was perfected, muskets became obsolete. Another weapon that firearms replaced was the bow and the crossbow. Since bullets were sent at a higher speed than arrows, they were deadlier weapons. The use of archers slowly declined throughout the century.

Even though bows and crossbows were becoming less popular during the 17th century, they weren't totally replaced. They were still used in battle and were very effective weapons, proving why they had been in use for centuries.

The crossbow was a stringed projectile weapon. It was a bow which was mounted on a crosswise by a system of cord bindings or by a metal bridle, a tiller, which was attached to a wooden shaft. A shaped disc called a nut was mounted with its axis across the stock. The nut was grooved on the upper surface to serve as a runner for the

bolt.

In the first half of the 17th century, the crossbow was used for hunting in countries like Italy, France, and Spain.[28] This weapon was used to bring down large and dangerous animals like wolves, bears, and stags. There were other types of crossbows like the stone and bullet crossbows which were used to hunt small animals. Later on in the century, stone and bullet crossbows were used for sporting purposes, especially in Germany, Belgium, England, and Switzerland.

Another type of crossbow called the light crossbow was also in use at the time. It was a small crossbow which was usually made with a steel tiller. This weapon could easily be concealed and was considered to be an underhand weapon. One of the unique features about this crossbow was that it had a reloading mechanism. This weapon was banned in the 17th century.

[28] Complete Encyclopedia of Armor and Weapons by Claude Blair [Pg 143]

17th Century Armor

By Christopher Teixeira

Cavalry Armor

The rise of the musketeer involved a decline in armor through the seventeenth century. The fullest armor was traditionally worn by cavalry, and important changes were made to the armor of the cavalry during this time. Some cavalry wanted to be quicker whereas others wanted protection. The cumbersome nature of armor was leading to a decline in use of certain parts of a suit of cavalry armor. The introduction of the musket and other firearms led to the development of two types of cavalry. The two types of cavalry were easily distinguished between the different types of weapons they used. The harquebusier would use a small gun where as the cuirassier would use pistols.

Figure 24: A typical set of armor worn by a cuirassier.

Cuirassiers wore a heavier set of armor. A typical set of armor is all plate armor from head to knee. Pauldrons, couters, and vambraces were used for protection on the arm: pauldrons covered the shoulders; couters, sometimes spelled cowters, protected the elbows; vambraces protected the lower arm from the elbow to the wrist. The part near the wrist of the vambrace was sometimes referred to as the cannon. They combined a couple pieces of armor and referred to it as an

elbow gauntlet or a bridle gauntlet. The cuirassier usually wore gauntlets on their hands because they did not deal with firearms as much. However, elbow gauntlets became more popular over the century because of the decrease in weight. Another option was to wear a fingered gauntlet which had a little more flexibility. The collar, sometimes called a gorget, protected the throat. They would also wear a collar which would connect the helmet to the breastplate and backplate. Sometimes the collar was made of one sheet of metal where other times it was made of a few lames. To protect the legs, tassets were still used. Cavalry used to wear pieces called greaves to protect their shins and cuisses to protect the thighs in the centuries before. They would also wear poleyns to protect their knees. The cuisses would connect to the poleyn with leather straps and then the greaves were attached in the same manner to the poleyn. With the use of muskets and the decline in use of armor, tassets were lengthened to the just past the knee to make up for the loss of the cuisses, while greaves were replaced by high boots. The culet protected the rump of the soldier. The culet is made of several lames for some flexibility. Some of the bigger changes occurred in the breastplates and backplates. The introduction of the musket and other powerful firearms resulted in a need for a stronger, more durable breastplate. These breastplates were all tested before being worn. Muskets were fired into the corner of every breastplate in order to insure the durability of each piece. The peasecod breastplate has a long central ridge ending around the waistline. This was replaced by a breastplate, commonly referred to as a cuirass, with flat surfaces. The backplate remained fairly similar to backplates worn in previous centuries. It was shortened as part of the trend of using less armor on the battlefield and to reduce the weight. They also shortened to decrease the discomfort for the cuirassier.[29]

[29] Blair, Claude. *European Armour circa 1066 to circa 1700*. 145-149.

The cuirassier usually wore an open-face helmet. The open-face helmet developed from the burgonet close-helmet. It had a barred faceguard if anything at all. The big difference between the open-face helmet and the close-helmet was the bevor became barred. A Turkish version of the open face helmet worn by the cuirassier was called the shishake. Another common helmet worn by the cuirassier was called the Zischagge. This helmet has a single vertical bar coming down from the brim with a tail made of a couple sheets of metal. The Italian form of the cuirassier helmet was called the Todenkopf.[30] The Todenkopf was a type of close-face helmet. The unique feature about the Todenkopf is that the bevor is shaped like a bizarre human face. Similar to the Zischagge is the lobster tailed pot worn mostly in England. It would have three vertical bars extending from the brim with a tail made of a few sheets of metal like the helmet in Figure 27.

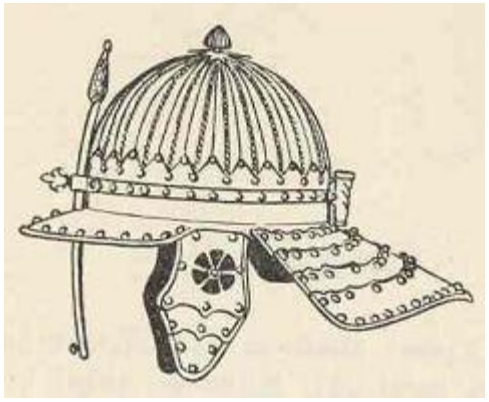

Figure 25: A drawing of a typical German Zischagge.

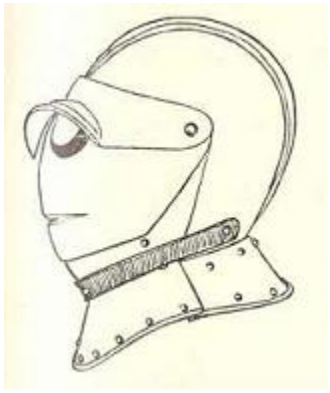

Figure 26: A drawing of a typical Todenkopf.

With the new improvements and use of firearms, another type of cavalry was introduced. This type of cavalry is referred to as arquebusier or harquebusier. Some also call them a carabineer. They got their name from because they were equipped with a harquebus, a small firearm. There are some differences in the armor that a harquebusier would wear compared to a cuirassier. In some cases gauntlets were still used but were being modified to fit the new weapons of the day. That means

[30] Blair, Claude. *European Armour circa 1066 to circa 1700*. 150.

for cavalry that used the old conventional weapons, gauntlets were still used. However, if a cavalryman used a firearm, a leather glove was preferred in order to be able to pull the trigger. The harquebusier would always wear leather gloves so that they could fire the harquebus with ease. The harquebusier needed more agility than the cuirassier therefore the suit of armor needed to be much lighter. There were many types of helmets used during this time, although morion style helmets were commonly used by harquebusiers. The morion helmets could be divided into two basic types. One type was the Spanish morion also called a cabasset. The other type was the comb morion with a high central ridge. A morion helmet was often used to help remove eyesight problems of a close-face helmet. The harquebusier also discarded the backplate. Shoulder pieces and even much of what covered the arms and legs was thrown away. Leather armor, referred to as a buffcoat, remained the only protection where plate armor used to be. A buffcoat was a jacket that consisted of a hide from an animal. The harquebusiers eventually started to only use the buffcoat and remove the plate armor that covered it. The buffcoat would not be as effective in defending a person, but would allow him to move easier and quicker. One piece of armor to be replaced by a leather counterpart was the gauntlet. Due to the need to be able to fire a weapon, a leather glove took the place of the iron gauntlet. Not all of these changes in armor were always the safest changes but where it lacked protection it made up for in the loss of weight.

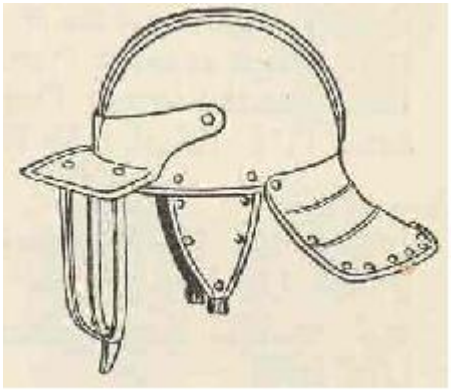

Figure 27: A drawing of a typical lobster tailed pot helmet.

Infantry Armor

Figure 28: A drawing of a musketeer.

During the age of the musketeer, there was a definite decline in the use of armor among the ranks of the infantry. Infantry needed to be mobile and agile in the battlefield when keeping to the formations. Even when not in battle, the amount of armor was an issue. Traveling on the military campaigns tended to be long and arduous. Therefore armies did not want to wear the heavy and cumbersome armor they used to wear during previous centuries. There were two basic types of infantry, pikemen, and musketeers. Pikemen used hand-to-hand weapons like a pike or halberd. Musketeers got their name from the muskets they used in battle.

Using a musket required a fair amount of agility and quickness. Musketeers considered the need for agility much more important than the actual protection received from the armor. Musketeers did not always have to resort to hand-to-hand combat and therefore did not need the extra protection that the pikemen would need. Hence plate armor was not very useful to them. Musketeers wore buffcoats instead of the usual breastplate and backplate. Overall the outfit that a musketeer would wear would not be noticeably different from that of a civilian.

Pikemen were very different from the musketeer. Since pikemen were concerned with hand-to-hand combat, they still needed protection. However, the pikemen still needed some agility and quickness when it came to fighting in battle. Also marching between battles was becoming more and more important with the increasing thickness of the armor they wore. Therefore they were discarding some of the armor they wore in previous centuries. Pikemen still wore mostly plate armor consisting of a breastplate, a backplate, and tassets. Like the cavalry, the breastplates and backplates were changing with the involvement of musketry into the battles. The breastplate that pikemen wore were very similar to that of the cuirassier. The backplate was also shortened a bit to lower the weight of the plate armor. In some places pikemen would wear pauldrons, but in the beginning of the seventeenth century pauldrons went out of style. Under the plate armor the pikemen would wear a buffcoat to give some protection for their arms and some padding under the breastplate. Pikemen wore unique helmets during this time known as a pikeman's pot. In the beginning of the seventeenth century the pikemen's helmet was known as a morion style helmet. The morion helmet was first developed by the Spaniards. The combcap became used more often than the morion style helmet. The

Figure 29: Pikeman: Pike ordered.

combcap had a wide brim with curved up edges in the front and back. There was also another type of helmet worn by the pikemen called birnhelm. The birnhelm helmet was more of a developed gothic iron hat. The English pikemen were known for wearing the plate armor the longest. However, towards the end of the seventeenth century the pikemen abandoned most of the plate armor if they wore any at all. The only pieces of plate armor they wore were the cuirass, the helmet, and the tassets towards the turn of the eighteenth century.[31]

Silk armor was introduced during the age of the musketeer. It was thought to be useful because of the idea it being pistol proof. Harquebusier armor was very similar to silk armor. Silk armor is, "constructed of wadding laid on a solid foundation, possibly leather, and covered with salmon-coloured silk."[32] Silk armor was used mainly for light defense.

There were a lot of reasons that contributed to the decline in armor during the seventeenth century. Armor was not light for any particular soldier. After the sixteenth century armor did not change too much in weight. A set of cuirassier armor weighed about sixty-nine pounds where armor for a pikeman was anywhere between forty-five and sixty-five pounds. Horse armor weighed about sixty-two pounds during the sixteenth century. It makes sense why there was a decline in armor when you consider the amount of armor that a horse or soldier would have to carry on the military campaign. Along with the weight, armor also presented a problem with protection. The decrease in weight meant a decrease in amount of armor which led to a reduction in protection. Infantry and cavalry still wore some plate armor, but certain places on the soldier's body were not

[31] Wagner. *European weapons and warfare*. 86.
[32] Blair, Claude. *European Armour circa 1066 to circa 1700*. 151.

protected. Certain places like the calves and arms were very vulnerable to injury. Although armor was thicker during the seventeenth century, it still did not provide much protection from the cold. This is another reason for the use of the buffcoat.[33]

Design and Manufacture

Design and manufacture of armor is very important. Armor did not just appear when you needed it for battle. It would take some time to create the massive amounts of armor needed for an army. It would also take skilled people to make the armor required for armies.

Manufacture of the armor was not very easy for the armorers of the time. Kings and other nobles made orders for huge amounts of armor. They would start with sheets of metal and slowly hammer and shape the pieces of the metal. The decline in use of armor led to less time spent on making it; therefore the quality of the armor was also lower. After the armorsmith was finished making the armor, the pieces were sent off to a millman. The millman would use a water-powered wheel to polish the pieces of armor. After being polished the armor would be sent off to the armies or to an etcher or a gilder to be decorated. A locksmith made all the hinges and buckles. The locksmith would send the buckles and hinges for the armor to the armorsmith so that they may be attached to the pieces of armor.[34]

During the seventeenth century armor was declining in use and so was the number of armorsmiths. Most people were not interested in joining a declining profession so

[33] Ffoulkes, Charles John. *The armorer and his craft, from the XIth to the XVIth century*. 105.
[34] Blair, Claude. *European Armour circa 1066 to circa 1700*. 188-189.

many people decided to become gunsmiths. Along with the decline of the armorsmiths was the decline of the quality of the work they produced. The decline in quality can be noticed in some of the pieces of armor produced during this time. Helmets during previous centuries were made of just a few pieces whereas during the seventeenth century helmets were made with many pieces. Another big difference can be noticed in the breastplate. The cuirass of the seventeenth century was flat and angular without molding. However earlier versions of the breastplate were a little more complicated and designed much better. The armorsmiths would even decorate the armor to make it look like an older style of armor because of the poorer quality they produced.[35]

During the seventeenth century, a guild existed for the armorers. The armorer's guild existed in order to keep the armorers in check. The guild regulated how many pieces of armor each armorer was able to produce in order to make sure one armorer was not taking work away from another armorer. To join the guild required that an armorer accomplish a few tasks. First they would take an exam to test their knowledge of the profession and techniques of the time. The armorer would then produce a work that would be examined by other armorers of the guild. The piece of armor would be assessed for the technique used and the overall quality of it. Sometimes they would produce a miniature model of a suit of armor to show their qualities. A smaller suit of armor is as difficult as making a good quality regular size suit of armor. The guild was very useful during that time because it allowed a little protection against bad work done by armorers. The existence of the guild also provided an incentive for armorers to produce a higher quality of work.[36]

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[35] Ffoulkes, Charles John. *Inventory and Survey of the Armouries of the Tower of London*. 96.
[36] Ffoulkes, Charles John. *The armorer and his craft, from the XIth to the XVIth century*. 120.

During the sixteenth century there were two distinct areas that armor was made. In the Italian city of Milan, some of the highest quality of armor was made. In Milan, it was mainly a family trade. The Negroli family and its relatives produced some of the best quality armor of that time both in decorative and overall defensive pieces. The other region known for producing quality armor was Germany. Although Germany produced higher quality armor, there was no particular family or part of Germany known for producing the armor.

Decoration of armor was a very difficult thing to do during the seventeenth century. Most decorated pieces of armor were of lower quality than pieces from the century before. The lower quality of decoration came from the different material that they now used for armor along with the same techniques used to decorate the armor. There were three main types of methods used for decoration of armor, engraving, etching, and embossing. These techniques were not that effective for decorating the armor unless they were done well, although they remained the most popular methods regardless of the quality of work they produced.

Etching was a popular method for decorating armor. The first step was to cover the piece of armor with a protective material that would not react to the acid used in the etching process. After the coating was applied, the design or pattern was scratched into the coating. Next the acid was used to etch the design. The most common acid used was a diluted nitric acid. After the acid was applied the armor could be washed with the design left neatly in the armor.

For engraving the armor a sharply pointed tool referred to as a burin was used. This method was not that popular because of the long time it would take to engrave the

designs into the armor. Sometimes the design or pattern would be painted onto the armor and then the background part of the design would be etched away. This was mostly used by the Germans during the age of the musketeer.[37]

Embossing involved actually shaping of the metal plates in the armor. While the other methods would make the design from the outside, embossing involved hammering the pattern from the inside of the armor. After hammering the design on the inside of the armor, details of the design were finished on the outside. This design was not used to often because of the long process in making the patterns and because the armor tended to become weaker with intricate designs.

Specialized Armor

Armor was also designed for other reasons than for protection of soldiers. Armor was not just for the soldiers in battle, but also for the horses they rode into battle on. Although like other armor, armor for horses was also in decline. Jousting and other ceremonial armor also existed but were not as popular as in the centuries before.

Armor was not just for the battlefield. Some of which was decorated for celebrations and gatherings. Many of these pieces of armor would not always be so feasible on the battlefield either. Many of the helmets were very beautifully done but lacked ability to see clearly. Other decorated pieces like the breastplate tend to be a little thinner for battle. Other specialized armor included armor for children. Mostly children did not go into battle so their armor was for ceremonies. They would be fully dressed in a suit of armor from helmet to breastplate to tassets. This armor took a bit of extra care

[37] Blackmore, Howard. *Arms and Armour*. 91-93.

since it had to be made to fit a small child. Another piece of armor used mainly for decoration during the seventeenth century was the target. The target was used in earlier centuries but was now being discarded due to its cumbersome nature. They still kept the target for ceremonies and other decorative roles.

Horse armor did not change much physically from previous centuries except for the decline in pieces used. The horse would wear a full suit of armor called a bard. The decline in use of armor left a horse wearing a chanfron and a crinet. The chanfron, sometimes called a shaffron, was a piece of armor used to protect the head of the horse and sometimes shield the eyes. The chanfron protected the whole head of the horse until the seventeenth century when the lower half of the chanfron was discarded. The armor protecting the neck of the horse was referred to as the crinet. Aside from the chanfron and the crinet the horse would not wear much else for armor. The horse still wore a saddle in which the cavalryman could ride on. Earlier centuries sometimes attached plate armor to the saddle but this became uncommon during the decline of armor.[38]

During the seventeenth century, people would also go hunting for sport. It was a common activity for people to do. They would wear armor and ride out into the woods with their dogs. The hunters would not wear a full set of armor necessarily but the typical armor of a cavalryman. The nature of the hunting dog to chase after the prey put the dog in danger of being shot by the hunters. To prevent the dog from being shot, it would wear a very crude armor. The armor would consist of mail and very little plate armor. A brightly colored feather was sometimes attached to the dogs chanfron type of armor so that the hunters could still see them while on the hunt.

Although jousting was not as popular as before, there was still a slight change in

the armor used for it. The armor used for jousting was called tilt armor. The set of tilt armor was not that different from a set of field armor. Tilt armor was most similar to the armor set of a cuirassier during the seventeenth century. They used a close-helmet with a one-piece visor. The breastplate was also similar except for a flange on the right shoulder, was used for resting the lance when it came time to joust. Another noticeable difference was the addition of a grandguard, was a piece of armor added to the left side to add some extra protection from the lance. The grandguard covered the lower left side of the helmet, the gorget, the left shoulder, and the left side of the fighter's chest. Spaulders were used in place of pauldrons for tilt armor. Spaulders were the same shape and defence as a pauldron just smaller. The jouster would use vambraces, mitten gauntlets, and elbow guards.[39]

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[38] Blair, Claude. *European Armour circa 1066 to circa 1700*. 184-187
[39] Blair, Claude. *The Complete Encyclopedia of Arms & Armor*.

Military Tactics

By Justin Gelito

Army Composition

The 17th century saw the beginning of the development of large standing armies. However, prior to the 17th century, armies consisted mostly of ad-hoc soldiers. They would fight during a seasonal campaign but once the war ended, these bands of soldiers would disband. These soldiers had ties to their own country and would only fight for their sovereign. Another type of soldier was the mercenary. These soldiers were not associated with a specific location and willing to fight for anyone for a price. They were self-equipped with their own supplies and arms and did not need any further provisions. As Europe progressed, these armies proved too temporary to keep up with the dynamic political landscape as well as the advancements in the field of arms and armor technology. More permanence was needed to develop a stronger military force.

Figure 30: Musketeer

Armies were comprised of the infantry and the cavalry. The infantry was divided mostly into two different groups, the musketeers, who used muskets, and the pikemen with their spears.

The musketeer was a foot soldier with a large musket as their primary weapon.

The musket's ignition system was that of the matchlock. The match was a long piece of slow burning cord that each musketeer would carry between his fingers. When not engaged in battle, the matches were not lit except for every 10th soldier in the ranks. This would allow quick response to an attack while minimizing the hazards of a burning match. These musketeers were equipped with two powder flasks, containing barrel powder and priming powder[40]. Eventually, the powder was kept in small cartridges for easier loading Single shot flasks of power became prominent in the English Civil wars. . In addition to the musket, musketeers would also carry a secondary weapon such as a sword or dagger. The musketeers did not wear armor. They wore only light clothing and relied on the range of their weapons as their protection. Other soldiers existed but were primarily differentiated by the use of a different weapon such as a caliver, a short gun or by wheelock muskets.

Figure 31: Pikeman

Though the musketeers had the firepower and range of their muskets, they were still very vulnerable to a charge by the cavalry. To protect the musketeers, and other soldiers, pikemen were employed in the infantry. Pikemen were issued pikes, a long spear. When grouped closely together and pikes held out, the pikemen could hold off an attack by the cavalry. The pikemen and their defense would only be effective if they were extremely disciplined. Group cohesion is paramount in the use of the pike to deter the enemy cavalry. In addition to the pike, pikemen also carried swords and daggers like

[40] Wagner. 18

the musketeers. But because the pikemen were more exposed to hand-to-hand combat, they wore armor. A pikeman would have a breastplate with a backplate and two plate tassets and a morion-style helmet. Other types of soldiers also existed such as targeteers, using a large target, or circular shield as their protection.

The other portion of the army, the cavalry, was also divided into different subgroups. They were divided by the type of weapon they were issued and the level of armor. The light cavalry soldier was known as an arquebusier, for he carried the arquebus, a short-barreled, musket, also known as a carbine or harquebus, so that the arquebusier was also referred to as the carbiner and harquebusier. As the light cavalry, the arquebusier was only equipped with a breastplate and a morion-style helmet for protection. The arquebusier was also issued extra pistols as a secondary weapon. As the light cavalry was more mobile with less armor, they were the group that reached higher numbers.[41] The arquebusier was the main soldier of the cavalry. The arquebusier served as a scout or as quick skirmish soldiers. They were mobile and were quicker than their heavily armed counterparts, the cuirassier.

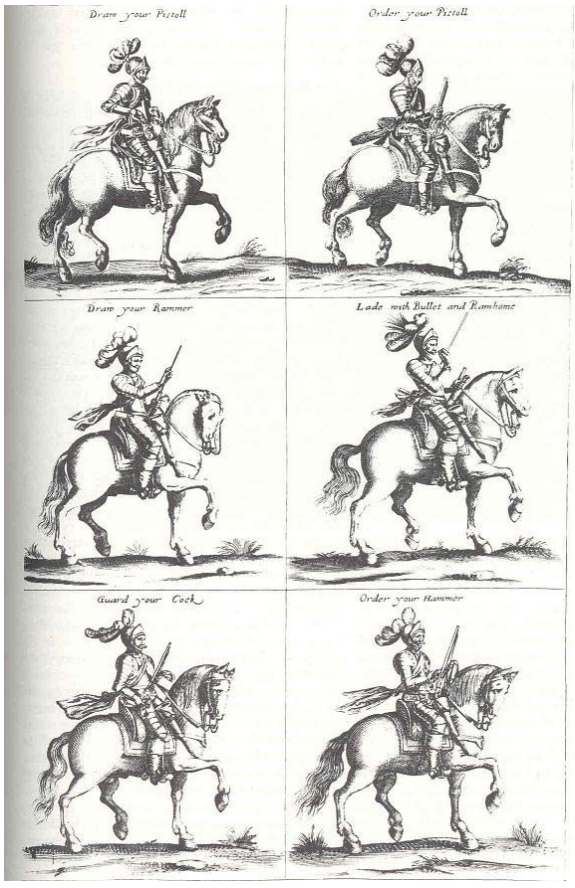
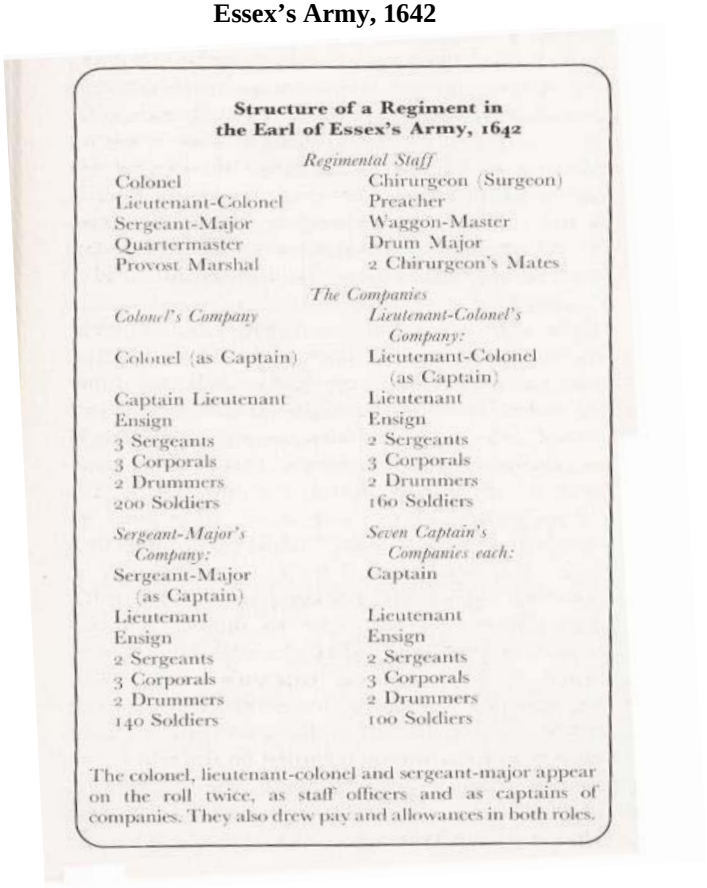


Figure 32: Arquebusier

The other group in the cavalry was the cuirassier. The cuirassier was heavily

armored. These soldiers were protected from head to knee with plate armor. Their arms were covered by pauldrons, couters, and vambraces, while gauntlets protected the hands. The entire thigh was protected by tassets, while a heavy cuirass, the frontplate of which could withstand a musket hit, protected the torso. In addition to the armor, the cuirassier was equipped with a heavy backsword as the primary weapon with two pistols as secondary weapon. Sometimes the cuirassiers had lances. With the heavy armor, these troops were used as shock troops in battle.

Table 1: Heirarchy of a Regiment in the Earl of Essex's Army, 1642



Structure of a Regiment in the Earl of Essex's Army, 1642

Regimental Staff

Colonel	Chirurgeon (Surgeon)
Lieutenant-Colonel	Preacher
Sergeant-Major	Waggon-Master
Quartermaster	Drum Major
Provost Marshal	2 Chirurgeon's Mates

The Companies

Colonel's Company	*Lieutenant-Colonel's Company:*
Colonel (as Captain)	Lieutenant-Colonel (as Captain)
Captain Lieutenant	Lieutenant
Ensign	Ensign
3 Sergeants	2 Sergeants
3 Corporals	3 Corporals
2 Drummers	2 Drummers
200 Soldiers	160 Soldiers
Sergeant-Major's Company:	*Seven Captain's Companies each:*
Sergeant-Major (as Captain)	Captain
Lieutenant	Lieutenant
Ensign	Ensign
2 Sergeants	2 Sergeants
3 Corporals	3 Corporals
2 Drummers	2 Drummers
140 Soldiers	100 Soldiers

The colonel, lieutenant-colonel and sergeant-major appear on the roll twice, as staff officers and as captains of companies. They also drew pay and allowances in both roles.

If they had one, both the arquebusiers and the cuirassier would carry their carbine slung on their backs on a leather bandolier. Their pistols would be held in leather holsters on the horses. In the 17th century, there was also another type of soldier, which can be looked upon as a combination of the infantry and cavalry. These soldiers were called dragoons. They rode horses into battle, but they would dismount at battle and then fight as a regular soldier in the infantry. This style of fighting is due to their

[41] ECWSA Handbook

training, dragoons were trained similarly to the infantry with exception to the basics of riding. They were not trained to fight on horseback like the cavalry. They therefore carried an infantry-style weapon, a dragoon musket, which was based on a matchlock ignition system that is almost impossible to effectively use on horseback. These muskets were lighter and less cumbersome than the traditional matchlock muskets that the musketeer used, as the dragoon would need to ride his horse with his musket comfortably. The dragoon was not a major component of the army, in beginning of the Thirty Year's war, there was only one regiment of dragoons.

Organization of the Army

With the steady growth of armies, organization and execution of strategy was becoming extremely important for the effectiveness of the army. At the onset of the 17th century, the focus of leadership positions goes from those of noble birth to veterans with their combat experience. As a result, armies are becoming more disciplined and more effective on the battlefield.

The infantry's smallest unit was the squad. They were a small platoon sized group of about 24 soldiers commanded by the corporals. The squads formed a battalion. The battalion would typically have about 300 soldiers. A battalion was commanded by a captain with a lieutenant as his deputy. The lieutenant supervised the training of the troops. The ensign of the battalion was elected by the enlisted men and was in charge of carrying the colors of the battalion. He would be next in command and would take over as captain or lieutenant if needed. The battalion would also have officers to tend to the

administrative affairs. The sergeant was placed in charge of the guards and sentries. The mustermaster kept the roster of the battalion and would also keep records of supplies and provisions. Other officers and non-commissioned officers within the battalion were lance corporals, first and second-class corporals as well as a surgeon and the drummer[42]. The drummer's role was to convey commands and communication across the fields of battle.

The regiment would be a group of five to ten battalions. Ideally, this would mean that a regiment would have 1500 men or more, but in wartime conditions this number would often drop to about 800 men. The colonel commanded the regiment with a lieutenant colonel as his deputy. Similar to the battalion, there were officers who held administrative duties within the regiment. There was the sergeant major, who was next in command, the regimental quartermaster, the regimental judge advocate, the provost, and the executioner. The regimental quartermaster's duty was to organize the supply lines to the regiment. The regimental judge advocate and provost were the officers of military justice. Each regiment also had their own chaplain.[43]

The organization of the cavalry was extremely important as the cavalry units were more mobile and would need greater care to organize. The basic unit of the cavalry was that of a company consisting of 80 to 90 riders. In command of the company was the captain. His deputy would be the lieutenant. The company would also have a sergeant in charge of guards and sentries. The cornet of the company would carry their colors. For the dragoon companies, they had an ensign as with the infantry. The company would also have their quartermaster, mustermaster, and surgeon. The company would employ buglers to convey commands with the dragoons having a drummer. The company would

[42] Lord Praissic 123
[43] Lord Prassaic 124

also have two or three corporals as their non-commissioned officers as well as a farrier to care for the horses and an armorsmith to repair the soldier's armor.

The cavalry regiment would consist of around five to ten companies. The colonel would command a regiment. Colonels would often raise and organize many regiments. The colonel of a regiment he raised himself would be referred to as the colonel proprietor. The colonel's deputy was the lieutenant colonel and much like the staff of the infantry's regiment, there was a sergeant major, regimental quartermaster, regimental judge advocate, provost, executioner, and chaplain. The regiment would have an adjutant to assist in administrative affairs as well as a wagonmaster to maintain wagons. The regiment also had a drum major to send commands to the companies.

Groups of regiments were commanded by generals. The supreme commander of the entire army would be the generalissimo.

During the 17th century, the cavalry was only about 30 percent of the total army[44]. The arquebusier was the major portion of the cavalry. The cuirassiers were still important as shock troops but were limited due to the expense of the arms and armor as well as the special training. At the beginning of the 17th century, the pikemen was more prominent in the infantry. However, the musketeers began to outnumber the pikemen as firearm technology and strategic use of firearms improved. At the beginning of the 17th century, the ratio of pikemen to musketeer was 3 to 1, but as the century progressed, the ratio seemed to even out and in some cases, would reverse to a ratio of 1 to 3[45].

As more men joined the army and chose it as their career, armies began to grow in size. Armies and their military power would enhance political powers. Countries like

[44] Ellis 231
[45] Wagner 18

Spain soon had huge armies, with numbers reaching 300,000 in the 1630s. This eventually leads to other nations trying to keep up and raising their own armies to help match against such large armies. Sweden's Gustavus Adolphus had about 180,000 men and England had about 85,000 soldiers.

Training

The training of a soldier took quite a bit of time. At a soldier's enlistment, the soldier would first learn his basic commands and drills from his sergeant. These drills were the basic positions and motions used when handling their weapon. For instance, the drills of a musketeer would include a motion to prime their musket and another motion to load their musket. After the basic instructions are learned, training is done with the large battalion. According to Barriffe, this portion of training is referred to as the First Days of Exercise. Soldiers are taught the proper distances when in rank and file and eventually they will practice a skirmish. The musketeer squads practice various movements. The pikemen squads practice different charges and protective movements to protect the musketeers. After that portion of training is complete, the Second Days of Exercise are executed. Drills, motions, and distances are again reinforced. The primary focus is now more complex troop movements and formations. In the musketeers, triple firing, the three front lines of a squad firing at the same time, is

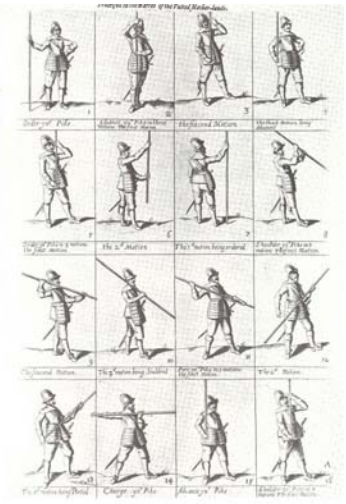


Figure 33: Pike Drills

introduced. Training continues with the Third Day of Exercises. Counter marches and doublings are introduced. This gives the battalion the ability to quickly form complex formations. Musketeers can form open squares and wedges with pikemen being able to protect from the flanks and the rear. The complexity of formations and movements continue up to the Sixth Day of Exercises. The repetition of the movements and commands enable the soldiers to complete their training after several weeks[46].

An enlisted man may rise up in rank. Officers were valued based upon their combat experience. An enlisted man may be considered a higher position based on experience and their leadership qualities. Since the higher ranked officers needed to take care of administrative work, an experienced soldier who had the abilities to read and write would be able to work their way up to sergeant. These men are usually not given a formal education and they will usually end up as a non commissioned officer. This being the case, higher ranked officers, like captains and colonels, would have to be fairly educated, this involving a person of upper class. An officer would gain promotion by garnering the trust of his superiors. The officer would undoubtedly spend increasing amounts of time learning from his superiors and learning from commanding his own troops. Eventually, when newer soldier troops are gathered, an officer may get a recommendation for a commission to command a larger group such as a battalion.

[46] Barriffe 147

Logistics

The increased growth in armies created a need for proper organization as well as the need for coordination between battle groups. Clear lines of communication were vital to the effectiveness of an army.

Table 2: Average Salary in the English Army, c.1630

Staff	*Pounds*	*Per Day Shillings*	*Pence*
Colonel	1	4	0
Lieutenant-Colonel		12	0
Sergeant-Major		8	0
Preacher		4	0
Provost		4	0
Chirurgeon		4	0
Quartermaster		4	0
Wagon-master		3	0
Chirurgeon's Mate		2	0
Drum Major		1	4
Company	*Pounds*	*Per Day Shillings*	*Pence*
Captain		12	0
Lieutenant		4	0
Ensign		3	0
Sergeant		1	4
Corporal		1	0
Gentleman at Arms		1	0
Drummer		1	0
Clerk		1	0
Lanspassadoe		0	10
Soldier		0	8

Conditions in battle were loud and hectic which called for non-verbal communication. Commands were sent on the battlefield with the use of drummers. Soldiers were trained to recognize drum orders. The cavalry had a different set of commands that were conveyed through a cornet. In the 17th century, battles were fought in open fields. Orders were sent down from commanding officers who were able to see the entire battle and would make decisions regarding their strength and location. In addition to the communication aspect of a mobile army, was the problem of actually traveling. Armies were swelling in size and therefore, when away for long campaigns, armies would need coordination with their supply sources.

A typical soldier in wartime during the 17th century was not really highly paid. His typical wage would be similar to that of an unskilled laborer[47]. The soldier would be

[47] Hall

paid monthly and would also have been paid with credit with the sutlers, the traveling merchants that followed the soldiers around.

Daily supplies were usually kept by the supply train of sutlers which followed the armies on their campaigns. They sold food and clothing to the soldiers as well as equipment repairing. Though the soldiers were weary of any suspicions, the mustermasters and quartermasters were authorized to seize any supplies if sutlers were found to be dishonest in their sales. These wagon trains, in addition to supplies, had women for the cleaning of clothes and their repairs. Women would also have the additional role as prostitutes for the soldiers. Women would also follow the soldiers on their campaigns and launder the clothing of the soldiers.[48]

The supply trains had to be continually restocked as the army kept maintenance on their campaign. This meant that the routes that the armies took must allow for supplies from the home country to be easily sent. This involved choosing to camp near a main river or waterway[49]. If in hostile territory, armies also had the option to pillage towns and village they came upon. This eventually led to villages and towns to provide payment in exchange for protection against enemy armies and their plundering. Villages would pay an amount of money and would receive written word with which they were protected for a certain amount of time[50].

While on a war campaign, armies were often in their enemies' territory. And so, to prevent the possibilities of surprise attacks and losses of supplies, the army would camp out in a fort-like manner. The locations of these camps would as stated before, by rivers, to facilitate the renewal of supplies and news and information, or out in large

[48] Wagner
[49] Parker 76

fields of farms. Mountains and valleys, as well as deep forests were not primary choices for encampment as they could prove prone to attack and surprise[51]. To create the camps, soldiers would dig out trenches to surround the camp, placing artillery to guard the perimeter while the higher ranked officers would stay quartered in a large travel tent or a cabin. The soldiers would stay in small tents, lined up with the rest of their regiments. At encampments, the cavalry was separated from the infantry. While at camp, the soldiers rested and replenished their supplies. Their armor was fixed and clothing was cleaned and mended. Officers would plan their tactical maneuvers as well as receive news and information concerning their home country and the enemy.

On long campaigns, with soldiers facing multiple battles, field hospitals were essential. They were sought after as they would provide care and rest for injured soldiers allowing a speedier recovery enabling them to go out into the battlefield again. This was a favorable arrangement as it was more cost effective to hospitalize wounded soldiers away while on campaign than to retrain new soldiers from the home country and to ship him to the front lines[52]. These soldiers would be more experienced than new soldiers and would be a fraction of the cost to take care of them than to retrain and equip new soldiers.

Strategy

Strategy and military theory in the 17th century were on the rise. With the strength and numbers of large standing armies, generals started to apply military theory in their tactics and strategy out in war.

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[50] Parker 77
[51] Lord Prassaic 158

The officers of the armies at the time were very well educated. They had studied the classics as well as history, and so a very large portion of their military strategy education was derived from the strategy of the ancient Greeks and Romans. The organization of the armies was actually derived from the organization of the classical armies. With extensive study in classic warfare and techniques, Maurice of Orange revamped the strategy and training for the Dutch. He incorporated extensive use of drill and parades. These drill techniques maximized the effectiveness of the musketeers. Musketeers were now spread apart for maximum attack area while providing a harder target for the opposition. Maurice also introduced the concept of volleying their musketeers[53]. Lines of musketeers would take turns firing and reloading to provide a constant series of firings. Since ancient armies utilized pike soldiers heavily, a number of their tactical formations and commands are studied. The armies would study movements of distances, facings, doublings, countermarches, and wheelings. This enabled better mobility and attack and defense techniques for the commanders.

In addition to the study of classics, the officers of the time also studied the strategies of their contemporaries. Gustavus Adolphus had an extremely effective formation which relied heavily on pikemen. The English military theorist William Barriffe himself would study the "Swedish Brigade" and the reason for its effectiveness. The formation of the Swedish Brigade was highly flexible in that it could quickly adjust to attack or defend as the battle dynamics dictated. The training of the soldiers within the Swedish Brigade was also a template to other officers. The soldiers of Adolphus were

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[52] Parker 72
[53] Roberts 4

renowned as a group of the greatest discipline and training.[54] Such reliance on pikemen imposed the need for such great discipline.

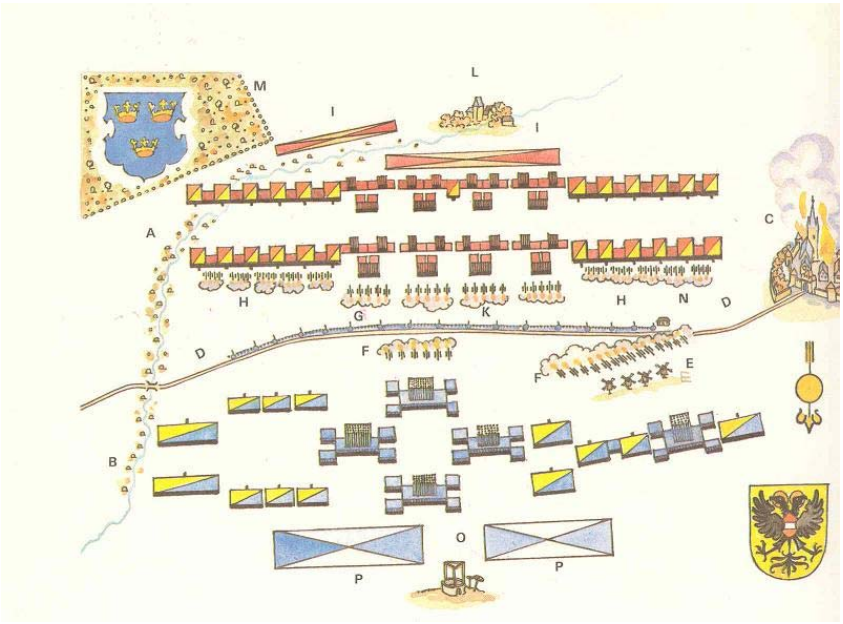


Figure 34: Swedish Brigade

Previous to the new application of strategy in warfare, armies would just attack and wage a battle and then clean up and recuperate until the next advance. This did not have any particular strategy but eventually strategic movements were used. Adolphus had a great strategic duel with another figure of military strategy, Wallenstein. As they engaged in battle, Wallenstein strategically attacked supply lines, leaving them in a position of control over the supply lines as well as the weaker portion of Adolphus's allies. War was now a battle of position and mobility as well as supply and direct attacks. Other uses of strategy within war were exemplified by Oliver Cromwell and John Lambert. Cromwell was the general of the parliamentary army in England and Lambert was a colonel under Cromwell's command. Lambert effectively engaged the Scottish forces of James Hamilton as well as quelled any Royalist uprisings to allow Cromwell's

[54] Barriffe

forces to return from Wales. While Lambert skirmished with Hamilton, Cromwell used the delay to gather supplies and support from the people of the area.[55] Officers would study such movements and tactics. They would have to realize that strategic movements were now essential in addition to the strength of forces.

Major Battles

In the 17th century, there were two phases in warfare. The first phase consisted of the Thirty Years War. It was a war based on the religious ideology. The fight was based upon the Habsburgs and their fight to retain power in the German states. This war involved the Protestant nations of Sweden and Denmark as well as the Protestant uprisings in Bohemia. They would rival the Holy Roman Empire of Spain and her allies.

The Thirty Years War lasted from 1618 to 1648. Its conclusion prevented the unification of the German states.

A major commander and strategist in the Thirty Years War was Gustavus Adolphus of Sweden. His adaptation of Maurice of Orange's techniques in military formations was highly successful. He used thinner ranks but with extra mobility, perfect for the application of firearms. He also reinforced the usage of the sword as the primary weapon of the cavalry.

The great military leader of the Holy Roman Empire was Albrecht Wallenstein. He was the best recruiter at the time, amassing a totally fresh new army to fight for the Catholic cause within weeks.

The two commanders met at the Battle of Lutzen in 1632. The Imperial forces

[55] Hart 87

were ready to make their winter quarters when Wallenstein received word that Adolphus and the Swedish troops were coming to attack. Wallenstein was slightly outnumbered and sought out the support from another Imperial general Gottfried zu Pappenheim which was too far to offer assistance in time for the attack. The battle took on for the day with Adolphus fighting beside his troops to improve their morale. Pappenheim finally arrived with his troops and all drove the Swedish troops back from their attack. Adolphus died in battle later in the day. The Swedish troops consequently surged another attack in support for their commander and won the battle. With the Swedish win, the Protestant forces were able to continue the war for another 18 years.[56]

The other phase in the 17th century involved the English Civil War. This war took place between 1639 and 1651. It was a civil war between those loyal to Charles I of England and those in favor of the Parliament. The war also involved the kingdoms of Scotland and Ireland. At the time, Parliament was not permanent but an advisory board for tax purposes. The parliament was displeased with the performance of a general who Charles I appointed and dismissed him. Charles I dissolved the Parliament in retort. Without the Parliament, Charles I was not able to raise money for his kingdom. With this economic situation and Charles I refusing to grant Parliament's authority, the English Civil War started. Parliamentary armies were formed to restore power to Parliament and to quell an uprising from Scotland and Ireland.

The most famous of all Parliamentary armies was the New Model Army. Its commander being Oliver Cromwell. Cromwell's style of fighting was based largely on the Dutch style of training and discipline of which Maurice of Orange originally wrote. He utilized light cavalry to quickly hit and run the flanks of their enemies.

[56] Hart 83

Conclusion

The IQP experience for the team proved to be very positive. Each team member found the work rewarding. The group was originally formed by Chati, Chris, Miguel, and Justin. They were previously friends with each other. Ty Bailey also signed up for the project. We were interested in doing an IQP within Worcester with a bit of hands-on experience. The Higgins Armory IQPs proved to be a great fit to our interests. This grouping was lucky in that everyone got along very well, and everyone was comfortable working with each other. This helped the group dynamics in that the working atmosphere was relaxed and the team members looked forward to working in the museum. The experience of working among the artifacts at the armory was very interesting. The hands-on work with the artifacts provided a great contrast to the regular class schedule at WPI.

The positive experience was possible due to the organization of the IQP. The amount of work accomplished during the three terms is very large. The PQP is extremely important to organize the workload into manageable weeks. The PQP was completed during A Term 2004. It consisted of many meeting on a weekly basis to plan out the upcoming terms. The PQP proposal organized the information that the group needed to research. The PQP was arranged to provide a weekly timeline of objectives that should be completed. The PQP also organized the information to be researched into distinct topics with detailed guidelines with which determined the range of information the entire IQP will eventually cover. The many artifacts that needed to be catalogued and photographed also need to be organized prior to the photography term. During this PQP

portion, we also had the opportunity to see previous topics and their projects. This helped the group to see what we had to do for the IQP. These previous projects also helped in that their bibliographies helped in finding the proper references. Within the PQP there was also a helpful process was the instruction of the handling procedures. This provided us with the knowledge of properly handling the artifacts before the actual photography session.

The first portion of the IQP was the research portion. In this term, we divided the IQP into several topics that fell within the scope of the 17th century. Ty, Miguel, and Justin researched the more historical topics such as, History, Technology of the Time, Military Strategy, respectively, while Chati and Chris researched Weapons, and Armor, again respectively. This enabled us to cover a wide range of information that would also be very detailed. Each week the team members researched the designated section within their own topic and wrote a draft of the report. Each week added another section to their topic. This approach did have difficulties, however. With so many team members, the coordination of all the team members' schedules proved difficult. The Higgins Library within the Armory was only available during the week and so finding time to get to the Armory for research was difficult. The research phase of the IQP almost seemed independent, with each person researching his own section. This proved to be a disadvantage when cataloguing in the future.

The next phase of the IQP was the photography. This portion held the greatest experience for the team. The team members would have a 2 hour session at the Higgins Armory where we would photograph and catalogue artifacts that were within the scope of the project. This experience gave the team a hands-on approach in learning the curatorial

side of history, as well as the delight of discovering certain information from close inspection of the artifacts. At first, only Chris or Chati would be able to write descriptions about the artifacts as they were exposed to more information due to their report topics. But with Professor Forgeng's help, we began identifying special details that we would otherwise have overlooked. If the team would share each other's research, then the team, as a whole would be more prepared for helping the descriptions. Other than that, the photographing portion of the project went very smoothly. The team split up the work so two students would photographs while the measurements descriptions and weighing were done by the other three students. This approach provided an efficient method to catalogue and photograph the large number of artifacts.

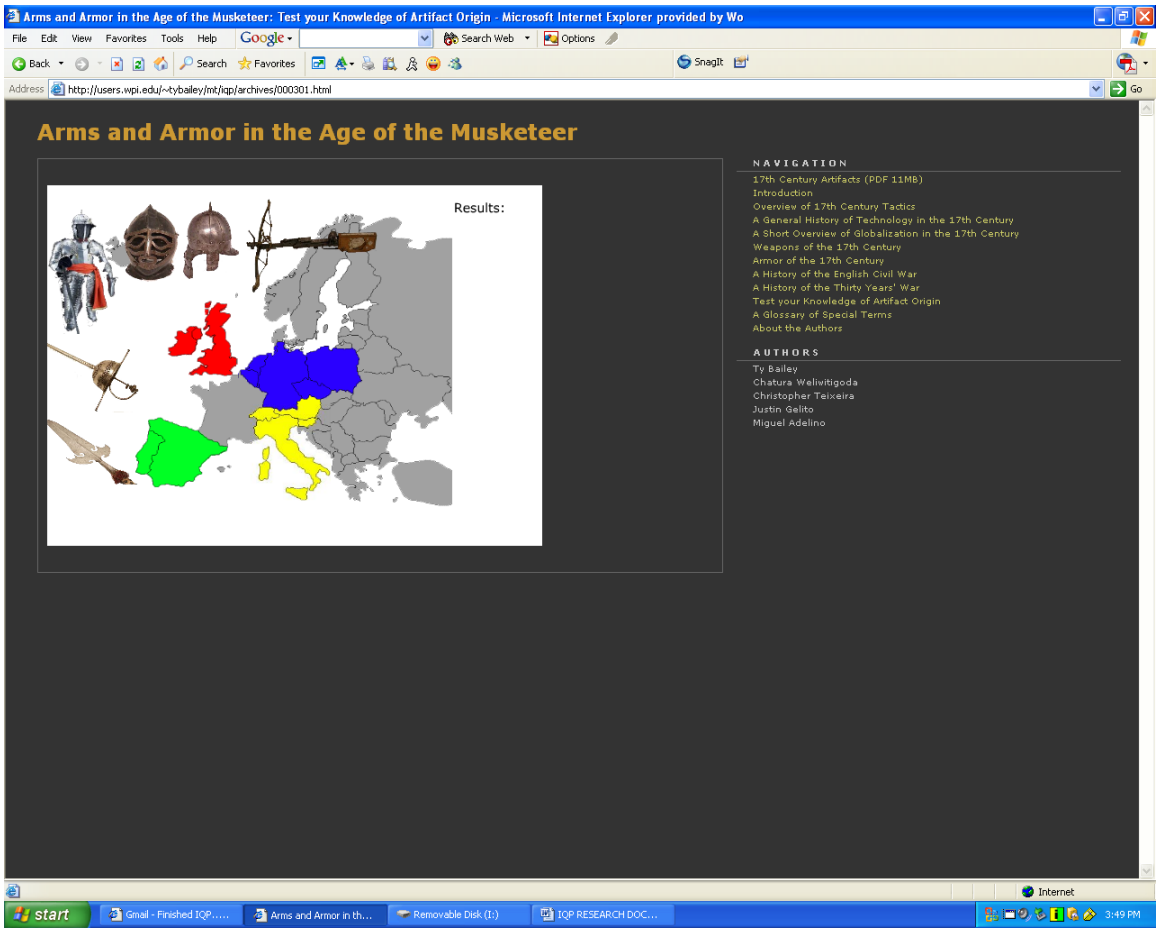
The last portion of the IQP includes the finalization of the project. The reports were completed and tied together and the internet portion of the IQP was set up. The internet portion was created by Ty almost exclusively as he had the most experience in coding. A setback was that the previous projects were PHP based, the servers at WPI recently banned the usage of PHP based websites, and so Ty had to develop another way to place our project on the internet. He found a solution that was based on internet blogs that worked well for the project. The internet component also features an “eye candy” portion that provides an interesting way to teach about artifacts within the scope of the project. The team’s component was a Flash based game which showed various weapons and armor components and a map of Europe. The object of the game is to match the artifact to its country of origin. The game would provide insightful information about the artifacts and its ties to the country of origin.

The experience left the group with a greater appreciation for the work done by

museums and their curators. The project gave the group a far different approach to understanding history, with hands-on experience with over a hundred different artifacts from the 17th century.

Appendix: Website/Visual Component

Although the digital aspect of this project was not the most important aspect of our research and application, it is worth noting what methods were used in its development and what techniques were used so that teams in the future may make use of our effort.



For the website it was decided that we would use a publishing system. After our initial research it was determined that the best available tool for our purpose was Movable Type (http://www.sixapart.com/movabletype/). We found that it gave enough freedom to allow us to adapt the software to meet the needs of our site.

The first thing that was done after the initial install was to disable the comment and trackback system. With those disabled, we would be able to have a clean site that would not have the danger of being attacked by ping floods or comment bombs. After comments and trackback was removed, we formatted the site in a very minimalist style that we found to have a professional feel, and was well suited to the material we were presenting. For this we used Cascading Style Sheets (http://www.w3.org/Style/CSS/), as well as a built in theme engine in Movable Type.

For the Visually interactive portion of the site, it was decided that Macromedia's Flash MX (http://www.macromedia.com/software/flash/)would be the best tool for our needs. Flash has a fairly steep learning curve, but many useful walkthroughs can be found on line; of particular note is the drag and drop tutorial found at http://www.video-animation.com/flash_07.shtml . We also made heavy use of Adobe Photoshop (http://www.adobe.com/products/photoshop/main.html) for the editing of the images found within the interactive section.

About the Authors


Ty Bailey is a graduating senior majoring in Computer Science and Humanities and Arts with a focus in History. He is a brother of Sigma Pi Fraternity and a committed member of Masque.


Chati a student at WPI and am majoring in Electrical and Computer Engineering. He hopes to work on air fighter jet defense systems when he is out of college.His interests include, hockey, basketball, reading etc.


Miguel Adelino is an undergraduate at WPI. He is pursuing a B.S. in Aerospace Engineering and is a current employee of General Electric – Aircraft Engines Division. He will also be doing project work at NASA's Glenn Research Center in the fall of 2005. He has concentrated his humanities and history courses in the areas of the Cold War Era.


Chris is a junior majoring in mathematics with a concentration in applied statistics. He plans on finishing his degree here and then going on to graduate school to get his PhD in statistics. His areas of interest include baseball, golf, biking, running and tennis.

Justin Gelito is an Aerospace Engineering major at WPI scheduled to graduate in the spring of 2006. His interests include cooking and sports.

Statement of Procedures

The Procedure used in the photography portion of the IQP is relatively straightforward.

Pre Photography

- Before the photography term, the group members must plan their schedule.
- Grouping similar items to be photographed in the same session would be easier as the studio set up will not be changed; for example, staff weapons would be photographed in the same session as the tripod and lights set up will not be changed to accommodate smaller artifacts.

Setup

- Prior to arrival, the artifacts should be already taken from storage. They will be grouped together on tables in the studio or placed in the storage room right outside the studio.
- The beginning of the session involves the set up of the studio. 2 tables, covered with protective foam sheets will be needed to hold artifacts as they are catalogued and photographed.
- The photography area will need 3 lights for the left, right, and above the artifact. The lighting must be placed to eliminate as much shadow as possible.
- A fresh portion of white background paper will be needed for the session if there are any markings on it.
- The camera's flash should also be turned off to prevent whiting out the artifact.
- The scale will be needed to weigh the artifacts as well as a tape measure to measure the artifact dimensions.

- A sturdy tripod will be needed to hold the camera. Make sure the legs of the tripod are fully secured as a fall will cause much damage to the camera.

Catalogue

- The cataloguing portion of the session involves taking the various measurements as well as a somewhat detailed description of the artifact.
- Special attention to markings, materials, and any noticeable differences should be the observed in the description.

Photography

- The photography of the artifacts begins with the removal of the artifact number tags.
- The tags should be placed next to the artifact on the table as to aid in the identification of the picture files.
- Each artifact should be photographed with multiple angles. Close ups to intricate detailing in the artifacts should also be taken.
- Special care must be taken to photograph pole arms and staff weapons, only the head should be photographed but photographed overhead with the staff at an angle.
    - Items such as full length lances were a problem. We placed the lance on an unopened table top on the floor, and then raised the tripod to the highest setting. This setting lacked enough lighting though, and the pictures came out very dark.
- Photographing within the Great Hall needs 2 maybe 3 lights.
    - Often times the artifact will be mounted on the wall and lighting will need

to be adjusted to reduce shadow.

- Lighting will have to be adjusted to reduce glare for the artifacts encased in glass.

Editing

The editing of the photographs was done by Adobe Photoshop.

- The photographs must be cropped and the identification tag must be digitally removed.
- The best picture of an article shall then be named after the artifact number such as "476.25.jpg", the other photographs will be renamed similarly but with the addition of a hyphen and counting number, similar to "476.25-1.jpg".

Website/Eye-candy

- The website was created by use of the Movable Type authoring engine, and the eye-candy portion of the site was created using Macromedia Flash.
- The website must have easy access to all the needed information about the project.
- The comment and archival features of Movable Type need to be disabled so that the site has a polished and professional feel.
- Simple lines and colors that can be created through CSS tags give the site an easy and global feel.
- The eye-candy is limited by the amount of space given within Flash.
- For the drag and drop capability it is suggested that one read the how-to found at http://www.video-animation.com/flash_07.shtml

- In the future it is suggested that on find a way to make the bounding boxes tighter around the movable objects so that they are less error prone.

Glossary

Assaying – process that determines the concentration of pure metal within a sample of ore

Backplate – plate armor that protects the back
Backsword – A sword with only one cutting edge
Bard – a full set of armor for a horse
Bardiche – A polearm fitted with a large crescent-like blade that extended far beyond the shaft
Basket Hilt – A hilt fashioned in an intricate weave pattern to protect the swordsman's hand during battle
Bastion – triangular extension of the tops of the walls at the corners of curtain walls
Bergmeister – local official for prospect mining
Bevor - chin-shaped defense for the lower face, using a gorget plate
Bayonet – A blade adapted to fit the muzzle end of a firearm and used as a weapon in close combat
Birnhelm – a type of helmet worn by pikemen that resembled a gothic iron helmet
Blast Furnace – a furnace which uses blasts of air to intensify the smelting process
Breastplate – plate armor that protects the chest
Buffcoat – a leather coat worn under armor
Burin – a sharply pointed tool used for engraving armor

Cabasset – a morion style helmet worn by Spaniards
Calcination – increase in weight of reactants during combustion, due to the bonding of air molecules
Caliver – An early form of longarm, lighter in weight than a musket
Caput – the top or head of a vein of ore
Carbine – A lightweight gun with a short barrel, designed for use by cavalry
Casting – technique used in metal shaping, where molten metal would be poured into a bronze mold until it cooled and hardened
Cauda – the bottom or tail of a vein of ore
Chanfron – armor for a horse protecting its head
Circumvallation Trenches – trenches dug around a besieging army to provide cover from the besieged army's attacks
Claymore – This weapon was used in the highlands of Scotland, by mercenaries during the 17th century. It had a straight, broad, double-edged blade, and it also had long, diamond sectioned quillons which were angled towards the blade. This blade was shorter than conventional two-handed swords, and was used by foot soldiers in battle.
Coke – purified form of coal and was used in metallurgic applications to make pig iron and steel
Comb Morion – a morion style helmet with a high central ridge
Contravallation Trenches – trenches dug by an army allied with the besieged to trap the attacking army between them

Couter – plate armor that protects the elbow
Crinet – armor protecting the neck of a horse
Cross Hilt – A shape of hilt that resembled a cross
Crucible – basic cup-style vessel that was used most often by an assayer
Cuirassier – a type of cavalryman that wore heavy armor
Cuisses – armor that protected the thighs
Cup Hilt – A cup like piece that was mounted onto a hilt to protect the swordsman's hand
Cupel – vessels used to hold the ore and molten metal that was placed in the furnace
Curtain – straight wall of a fortification
Culet – armor that protected the rump

Drawing – type of metal shaping process used in making tubes and wire where hot metal was pulled through a plate with holes drilled in it
Dusack – A curved single-edged sword

Ell – unit of depth in mining, approximately six inches
Enfilade – defensive strategy in which the attacker is constrained on his sides and therefore vulnerable to fire from the front
English Bill – A polearm which closely resembled a halberd, with differences in the shape of the blade

Falchion – Type of curved sword which contained a short,heavy, cleaver-like blade
Fathom – unit of length approximately equal to six feet
Finis – the end of a vein of ore
Fissure Vein – *See Vena Profunda*
Flintlock – An ignition system which consisted of a flint being struck against steel to produce a spark and light the gunpowder
Flux - basic compound, often in a cake-like textured form, which would lower the melting point of the elements within the ore
Forging – style of metal shaping where a heated piece of metal (ingot) is repeatedly pounded with a hammer over an anvil until a desired shape is reached
Four-year Crop Rotation – farming technique that would rotate fields using wheat, barley, turnips, and clover
Fuse rope – Rope used to ignite an artillery piece

Gauntlet – plate armor that protected the hand
Glacis - mound of earth placed against the wall in the form of an incline
Gorget – also called a collar protected the throat
Granguard – a piece of armor attached to the left side of the gorget
Greaves – armor that protected the shins

Halberd – A polearm that has an ax-like head with a steel spike in line with the shaft
Hanger – A curved short sword used for hunting
Harquebus – A light portable matchlock gun
Harquebusier – a type of cavalryman that used a harquebus

Head Meer – the largest meer in a mine, which was awarded to its discoverer. A head meer was approximately 294 square fathoms

Heliocentrism – theory that states that the sun is at the center of our solar system and that the Earth and other planets revolve around it

Hilt – Handle of a sword

Horizontal Waterwheel – type of waterwheel in which the wheel is horizontal (the circular shaped projection contacts the water). This type of wheel would be used to rotate the millstones in a gristmill

Howitzer – more modern mortar

Ingot – a heated piece of metal used in metal shaping processes

Investment Casting – type of casting, also known as the lost-wax method, in which a wax model of the desired object (called an *investment*) would be made and surrounded by a plaster-like compound. The compound would harden and then be heated until the wax melted, leaving the imprinted shape in the mold

Karabela – A curved sword that was in dominant use in Poland and Hungary during the 17^{th} century

Knuckle-guard – A guard on the handle of a sword to protect the knuckles of the swordsman

Lame – a single sheet of metal used in articulated armor

Lance – Also called a Horseman's spear, a staff weapon that was used by the cavalry

Langue de Boeuf - A polearm which had a triangular flat or long ribbed blade, was also considered an early version of the partisan

Lobster Tailed Pot – helmet worn in England known for its three vertical bars extending from the brim with a few lames attached to the backside to resemble a lobster tail

Lochaber Axe - A weapon consisting of a pole armed with an ax-head at its end, formerly used by the Scottish Highlanders

Lost-wax Method – *See Investment Casting*

Lucerne Hammer – A polearm which contained a four pronged hammer, also had a spear and a pointed beak

Mace - A heavy war club with a spiked or flanged metal head, used to crush armor

Main Gauche – Dagger meant for the left hand

Matchlock Ignition – An ignition system which required a slow burning match to make contact with priming powder

Meer – an area in which a miner was allowed to dig. A head meer was approximately 294 square fathoms, whereas an ordinary meer was approximately 196 square fathoms.

Metallurgy – process of extracting metal from the ground and making useful objects for mankind

Morgenstern – A weapon that had a ball and chain attached to short shaft. The ball had spikes with a "star" configuration

Morion – helmets worn by harqubusiers

Mortar - short-barreled canon that launches medium-sized shells to a high elevation for

short range

Musket - A smoothbore shoulder gun used in the 17th century

Musket rest – A pole which gave the barrel of the musket support while the musketeer was shooting

Musketeer - A soldier armed with a musket

Muzzle – the open end of a canon

Open-face Helmet – a helmet without a visor

Ore – mixture of metal or minerals and rock

Origo – the beginning of a vein of ore

Overshot Waterwheel – type of waterwheel in which water flows over the top of the waterwheel forcing the downstream side of the wheel to rotate downwards

Panning – process of using a pan with holes to sift the sand and sediment from water sources, most often rivers

Partisan – A pole-arm having a spear-point with lateral projections at its base, mounted at the end of a long shaft, used for mostly ceremonial purposes

Pauldron – plate armor that protected the shoulders

Pike – A thrusting pole-arm which was used by the heavy infantry, used as a defense from cavalry

Pistol – A gun designed to be held by one hand

Poleyn – plate armor that protected the knee

Pommel – The knob at the base of a sword

Priming Powder – Fine gunpowder used for the initial ignition of a firearm

Ptolemaic System – theory that stated that Earth lay at the center of the galaxy and that the sun, and stars, and planets all revolved around it

Quillons – The crossbar on a sword

Ramparts – the walls of a fortification

Rapier - A light, sharp-pointed and thin-bladed sword, used chiefly for thrusting

Rolling – type of shaping process that involves ingots being passed in between a set of rollers spinning in the opposite directions resulting in thinner, expanded sheets of metal

Saber – A heavy cavalry sword with a one-edged, slightly curved blade

Sap – trench dug by a besieging army to connect groups of soldiers together

Scorifier – a wide and shallow cupel used often in smelting or when fluxes were mixed with an ore

Scottish Dirk – Scottish dagger that was a descendant of the medieval ballock knife

Searlock – An ignition system that operated in the opposite fashion from the snap matchlock

Slag – molten impurities formed by reactions during smelting

Shaft-Tunnel Digging – method of mining using shafts dug into the ground or a tunnel dug into the side of a hill. Optimally, shafts would meet tunnels to provide light, air, and an easier transportation process.

Sheeted Vein – *See Vena Dilitata*
Shishake – Turkish open-face helmet
Smallsword – A derivative of the rapier that appeared in the latter part of the 17th century, having a shorter blade
Smelting – technique involving the melting or fusing of ore in a furnace, to separate elements
Snap-matchlock – An ignition system which was similar to the matchlock except was attached to a plate and had the ability to be cocked back and sprung to reach the priming powder
Staging area – lines set up 30 meters from a fortification to form ground based attacks on a besieged city
Stiletto – Small Italian dagger with a tapering blade
Stone Crossbow – A crossbow which shot stones as projectiles; usually used in Italy to hunt small animals
Stringers – small, thin veins of ore than fiber out from the main vein

Target – a type of circular shield
Tassets – plate armor that protected the upper legs to the knee
Todenkopf – close-face helmet known for its human shaped bevor
Touch Needles – set of 24 needles that contained different levels of gold and silver to which an assayer would compare a sample of ore rubbed on a touchstone
Touchstone – slightly rough, black stone usually made from quartz, jasper, or slate, which would be rubbed with a sample of ore. Assayers would use touch needles to examine the composition of the ore
Trebuchet – large catapulting siege engine

Undershot Waterwheel – type of waterwheel in which water flows beneath the wheel forcing the downstream side of the wheel to rotate upwards

Vambrace – plate armor that protect the lower arm
Vein – stream of metal-ore that flows towards the surface because of the internal pressures of the Earth
Vena Dilitata – a flat, wide deposit of ore also known as a sheeted vein
Vena Profunda – a wide stream of ore also known as a fissure vein

War Hammer – A large hammer-like weapon used to crush armor
Wheellock Ignition - A form of ignition for a firearm in which a piece of pyrite was held against a rotating serrated wheel to generate a spark.
Windlass – cranking device used to raise and lower buckets in a mine

Zischagge – German cuirassier helmet known for a single bar extending from the brim

Annotated Bibliography

General History

Ashton, Robert. *The English Civil War : conservatism and revolution, 1603-1649*. London : Weindenfeld and Nicolson, 1978

Fletcher, Anthony. *The outbreak of the English Civil War*. New York : New York University Press, 1981

Gindely, Antonín. *History of the thirty years' war*. New York, G. P. Putnam's, 1884.

Hibbert, Christopher, *Cavaliers & roundheads : the English Civil War*, 1642-1649. New York : Scribner ; Toronto : Maxwell Macmillan Canada : New York : Maxwell Macmillan International, c1993.

Pagès, Georges. *The Thirty Years War, 1618-1648.* New York, Harper [1970]

Russell, Conrad. *The causes of the English Civil War*. Oxford : Clarendon Press ; New York : Oxford University Press, c1990

Schiller, Friedrich. *The History of the Thirty Years' War in Germany*. Mass. : Dana Estes & Co., [n.d.]

Seel, G. E. (Graham E.). *The English Wars and Republic, 1637-1660*. London ; New York : Routledge, 1999

Stone, Lawrence. *The causes of the English Revolution, 1529-1642*. London, Routledge and K. Paul, 1972.

Supple, Barry. *Commercial crisis and change in England, 1600-1642; a study in the instability of a mercantile economy*. Cambridge [Eng.] University Press, 1959.

Trevor-Roper, H. R. (Hugh Redwald). *The age of expansion; Europe and the world, 1559-1660*. New York, McGraw-Hill [1968]

Wiseman, Susan. *Drama and politics in the English Civil War*. Cambridge ; New York : Cambridge University Press, 1998.

Technology

Bullok, Lynne. "A Midlands Coalmine in the 17th Century." Sealed Knot Knowledge Database. Vol. 33, Issue 5, Oct./Nov. 2001.

http://www.sealedknot.org/knowbase/docs/0074_Coalmine.htm.
Gives detailed account of miners in the Measham Coalmine, including wages earned.

de Vries, Jan. *The economy of Europe in an age of crisis, 1600-1750.* Cambridge University Press: New York 1976.
Applies reasoning to changes in economic trends in the 17th century. Topics include the development of agriculture and industry, foreign and regional trade, urbanization, a study of demand in explaining economic growth, the bourgeoisie, and the state.

Dennis, W.H. *A Hundred Years of Metallurgy*. Aldine Publishing Company: Chicago 1963.
Covers a vast history of the extraction of metals and their shaping. Mainly deals with the time period between 1850 and 1950, but does include technology prior to1850.

Dibner, Bern. *Agricola on Metals*. Burndy Library: Norwalk 1958.
Gives a summarized version of Agricola's *De Re Metallica* and a narrative on its influence.

Fisher, F. J. *London and the English economy, 1500-1700.* Hambledon Press: London 1990.
Deals with central features of the English economy, in particular the importance of London, both as a social and economic hub, and the nature of internal and external trade.

Grassby Richard. *The Business Community of Seventeenth-Century England.* Cambridge University Press: London, 1995.
Using records from private firms, the author discusses the dynamics of the pre-industrial economy and the interaction between business and society.

Hall, A. Rupert. *The Rise of Modern Science III: From Galileo to Newton, 1630-1720.* Harper & Row: New York 1967.
Gives detailed accounts of scientific advances in the 17th century including chemistry, physics, nature, and mathematics.

Holme, Randle. *The Academy of Armory*. Scolar Press: London 1972.
Contains numerous terms and explanations of tools and their uses in metalworking. Also contains information on building, clothing, leatherworking, and other crafts of the time period.

Hoover, Herbert Clark & Hoover, Lou Henry. *Georgius Agricola: De Re Metallica*. Dover Publications, Inc.: New York 1950.
Important scientific classic on mining and metallurgy. Predates 17th century slightly, yet offers more technological advancements than *The Pirotechnia of Vannoccio Biringuccio*.

Moxon, Joseph. *Mechanick Exercises or the Doctrine of Handy-Works* [1678]. Morristown NJ: Astragal Press, 1989.

Describes the various tools and their uses. Contains engraving plates and illustrations for over 170 tools.

Peacey, J. G and Davenport, W. G. (1979). *The Iron Blast Furnace*. New York: Pergamon Press.

This book discusses how an iron blat furnace works. This book goes in depth on the process the iron goes through in a blast furnace.

Singer, Charles, etc., eds. *A History of Technology*. 5 vols. New York and London: Oxford University Press, 1954.

A comprehensive yet concise chronicle of scientific inquiries ranges from the early Greeks (c. 600 B.C.) to the reaction to the 19th-century publication of *The Origin of Species.*

Smith, Cyril Stanley. *A History of Metallography - The Development of Ideas on the Structure of Metals before 1890.* The University of Chicago Press: Chicago Illinois 1992.

A very good source of information on damascus steel, Wootz steel, Japanese sword construction and mokume.

Smith, Cyril Stanley (ed). *Sources for the History of the Science of Steel, 1532-1786*. MIT Press: Cambridge 1968.

Compilation of works by various authors covering the forming and finishing processes of steel.

Tylecote, R.F., et al. *Metallurgy in Archaeology: A Prehistory of Metallurgy in the British Isles*. Edward Arnold Publishers: London 1962.

Covers the use of metallurgy in dating artifacts, but also gives explanations as to how people of the times created such artifacts. Goes from the Bronze Age into the 17th and 18th centuries.

Wagner, Eduard. *European Weapons and Warfare, 1618-1648.* Octopus Books: London 1979.

Text including information on artillery and siege warfare in the 17th century.

Wallerstein, Immanuel. *The Modern World-System II : Mercantilism and the Consolidation of the European World-Economy (1600-1750).* Academic Press: San Diego 1980.

Covers the agricultural origins and mercantilism of the European world economy in the seventeenth century.

Wikipedia. "Coke(coal)." http://en.wikipedia.org/wiki/Coke_%28coal%29.

Online encyclopedic reference that contains a brief history on coke.

Wikipedia. "Siege. http://en.wikipedia.org/wiki/Siege.
Online encyclopedic reference containing information on Marshal Vauban and his contribution to siege warfare.
Williams, Alan, and Anthony de Reuck. *The Royal Armoury at Greenwich 1515-1649: A History of its Technology*. Royal Armouries Monograph 4. Leeds: Royal Armouries, 1995.
A detailed account of the metallurgy and metal-smithing behind the artifacts.

Windelspecht, Michael. *Groundbreaking scientific experiments, inventions, and discoveries of the 17th century*. Greenwood Press. 2001.
This reference resource explores the major scientific and mathematical milestones of this era, and examines them from their scientific and sociological perspectives.

Wolf A. *A History of Science, Technology, and Philosophy in the 16th and 17th Centuries.* MacMillan: New York 1935.
Comprehensive book with a complete history on technology and its advancements in the time period. Covers instruments, astrophysics, mathematics, mechanics, electricity, meteorology, chemistry, medicine, structures, mining, metallurgy, steam power, and philosophy.

Weapons

Blackmore, Howard. (1965) *Guns and Rifles of the World*. London: Chancellor Press.
History on firearms and their introduction to warfare. Explains from what weapons they were developed and early techniques used as well as what weapons they replaced.
Blair, Claude, and Leonid Tarassuk, eds. (1982) *The Complete Encyclopedia of Arms and Weapons*. New York: Simon and Schuster. Names, history, and pictures of arms and weapons are included in this book. Explains who used what type of weapon and where they used it. Contains detailed info on swords, spears, axes, lances, bows, etc.
Coe, Michael D., et al. (1989) *Swords and Hilt Weapons*. New York: Weidenfeld and Nicholson.
A detailed history and development of different types of swords that were used in the Medieval Times. Also includes descriptions on different types of hilts such as: quarter hilts, half hilts, knuckle guards. Describes how different hilts were used depending on the type of sword.
Karcheski, Walter J., Jr. (1995) *Arms and Armor in the Art Institute of Chicago*. Boston: Bulfinch Press This book is a basic categorical listing of the arms and armor acquired by the Art Institute of Chicago. There are dates, brief backgrounds, and pictures.
Gardner, Robert Edward. (1936) *Arms fabricators, ancient and modern*. Columbus, Ohio: R.G. Adams.
A compilation of the names and dates of gunsmiths, blade smiths, armorers, bowyers and cannoniers offered with such pertinent data upon their lives and

activities as is discoverable together with 368 identified poincons.
Grancsay, Stephen U. (1986) *Arms & Armor*. New York: Metropolitan Museum of Art. Contains listings of specified armor and pieces. The list includes helmets, shields, shafted weapons, daggers, firearms, crossbows, shields, breastplates etc.
Hall, Bert S. (2002) *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics.* Johns Hopkins University Press. Contains information on the origin and evolution of gunpowder-based weapons and their impact on warfare in the Age of the Musketeer.
Nickel, Helmut. (1991) *Arms & Armor from the Permanent Collection.* New York: Metropolitan Museum of Art. Pictures of arms and armor from the Metropolitan Museum of Art. Information on where each arm or armor was acquired and where they were used in Europe and in which period of time.
Norman, A.V.B. (1985) *English Weapons and Warfare, 449-1660.* New York: Dorset Press. Contains a history of English warfare and the weapons they used. It provides information about the change in weaponry from the mid-fifth century until the mid-seventeenth century.
Norman, A.V.B. (1980) *The Rapier and Small-Sword, 1460-1820*. London: Arms and Armour Press. The rapier and small-sword's history and development are described in this book. Describes how each weapon was created and how each part was made. It includes information on hilts and how armies used both types of weapons.
Norman, Vessey. (1964) *Arms and Armour*. London: Octopus Books Limited It tells of the effects firearms had on armor and describes various weapon types
Snook, George. *The Halberd and other European pole-arms 1300-1650.* California: Museum: Restoration Services. This book describes the Halberd and other European pole-arms. Book contains detailed descriptions and illustrations of these weapons.
Wilkinson, Fred. (1978) *Arms and Armour*. London: Hamlyn Publishing Group Ltd. Contains information on different types of spears and bows. The efficiency of each type of spears and bows.

Armor

Arador Armour Library (2003), *Glossary of Armour Terms.* Available online http://www.arador.com/glossary/index.html An online glossary of armour related terms.
Blackmore, Howard. (1965) *Arms and Armour*. London: Studio Vista. A general history of arms and armor.
Blair, Claude. (1972) *European Armour* circa *1066 to* circa *1700*. B.T. Batsford, Ltd., London, 1958; 2nd ed. New York: Crane, Russak and Co.Has small section on armor used through the Age of the Musketeer including the most important achievements at the time and explains the phasing in of firearms and phasing out of armor worn.
Bull, Stephen. (1991) *An historical guide to arms and armor.* New York: Facts on File.

Describes portable arms and armor from the time of the Greeks and Romans to the early 19th century. Additionally covers various types of armor including sporting armor and hunting armor.

Burgess, E. Martin. *The Mail Maker's Technique*. The Antiquaries Journal Volume XXXIII, Jan.-April 1953.

Describes techniques used by blacksmiths and armorers.

Coggins, Jack. (1966) *The Fighting Man*. New York: Doubleday and Company. This book gives detailed descriptions of the methods of fighting for every era of time. It explains the different roles of the armor in the Age of the Musketeer.

Dean, Bashford (1915). *Collection of Arms and Armor Including the William H. Riggs Donation*. New York: Metropolitan Museum of Art. Categorical listing of most arms and armor from the William H. Riggs Donation with pictures and general history on each piece.

Ellis, John. *Cavalry* New York: G.P. Putnams's Sons, 1978. 357.1 E15c Shows the progression of the horseman throughout the medieval period. Has a focus on the adoption of mounted Pistoleers, which were becoming common place during the Age of the Musketeer.

Ffoulkes, Charles John (1945), *Arms & armament : an historical survey of the weapons of the British army.* London : G. G. Harrap and company ltd. Historical survey of the weapons of the British army.

Ffoulkes, Charles John (1909), *Armour & weapons.* Oxford, Clarendon Press. Information on armour and weapons.

Ffoulkes, Charles John (1913), *Decorative ironwork from the XIth to the XVIIIth century.* London, Methuen & co., ltd. Information on ceremonial and decorative armor.

Ffoulkes, Charles John (1916), *Inventory and survey of the armouries of the Tower of London.* London, H.M. Stationery off. Inventory and information on the London armouries.

Fliegel, Stephen N. (1998) *Arms & Armor, The Cleveland Museum of Art*. Cleveland: The Cleveland Museum of Art. General background info on categorical listed arms and armor in The Cleveland Museum of Art. Pictures included with captions and dates on where the arms and armor were from.

Fliegel, Stephen. (1997) *The Making of Armor*. Cleveland: The Cleveland Museum of Art. Describes all major manufacture techniques used by armorers. Describes certain suits of armor and how they were designed uniquely for individuals and troops.

Gamber, Ortwin. (1972) *Glossarium armorum.* Graz, Akadem. Druc- u. Verlagsanst. Glossary of armor, text is in Czech, Danish, French, German, Russian, Spanish, Polish and Italian.

Gardner, Robert Edward. (1936) *Arms fabricators, ancient and modern.* Columbus, Ohio: R.G. Adams A compilation of the names and dates of gunsmiths, bladesmiths, armourers, bowyers and cannoniers offered with such pertinent data upon their lives and activities as is discoverable together with three hundred sixty-eight identified poincons

Grancsay, Stephen U. (1986) *Arms & Armor*. New York: Metropolitan Museum of Art, This book contains listings of specified armor and pieces. The list includes helmets, shields, shafted weapons, daggers, firearms, crossbows, shields, breastplates, and back plates.

Hammond, P. T. (1986), *Royal Armouries : official guide*. London : Trustees of the Royal Armouries with Philip Wilson Publishers. The official guide to the Royal Armouries in London.

Hewitt, John. (1855-1860) *Ancient armour and weapons in Europe*. Oxford, London: J. Henry and J. Parker. Ancient *armour and* weapons *in* Europe: from the iron period of the northern nations to the end of the seventeenth century: with illustrations from contemporary monuments

John Woodman Higgins Armory (1961), *Catalogue of armor: the John Woodman Higgins Armory*. Worcester. Catalogue of armor for the Higgins Armory.

Karcheski, Walter J. Jr. (1995) *Arms and Armor*. Boston: Little Brown and Company. Includes armor terms and various names for each type of armor. Small amount of relevant pictures with descriptions.

Karcheski, Walter J., Jr. (1995) *Arms and Armor in the Art Institute of Chicago*. Boston: Bulfinch Press This book is a basic categorical listing of the arms and armor acquired by the Art Institute of Chicago. There are dates, brief backgrounds, and pictures of most items.

Nickel, Helmut. (1991) *Arms & Armor from the Permanent Collection*. New York: Metropolitan Museum of Art. Pictures of arms and armor from the Metropolitan Museum of Art. Tells where each arm or armor was acquired and where they were used in Europe and in which period of time.

Norman, Vessey. (1964) *Arms and Armour*. London: Octopus Books Limited. This book contains detailed descriptions of how mail, scale armor, plate armor and other related armor were developed. It also gives a look at who manufactured armor and what the finest achievements of the age were. It tells of the effects firearms had on armor and describes various weapon types.

Oakeshott, Ewart. (1980) *European Weapons and Armour*. North Hollywood: Beinfeld Publishing Inc. This book includes information on how the handgun was developed and used in battle. It describes various weapons such as staff-weapons, axes, maces and contains information on swords in the early 17th century.

Pfaffenbichler, Matthias. (1992) *The Armourers*. Medieval Craftsmen Series. Toronto: University of Toronto Press. Armourers are named in this book for their suits made and other arms they have developed. Also described is how the armourers had their own unique design for the pieces they created.

Roberts, Kieth and McBride, Angus. (1989) *Soldiers of the English Civil War (1): Infantry*. London: Osprey. A popular book includes basic information and pictures involving infantry of the English Civil War.

Royal Armouries (1996), *Royal Armouries Museum.* Leeds : Royal Armouries Museum Information on Great Britian's Royal Armouries Museum.

Stone, George Cameron. (1961) *A glossary of the construction, decoration and use of arms and armor in all countries and in all times, together with some closely related subjects.* New York: Jack Brussel Pub. A weapons and armor dictionary.

Tincey, John. (1990) "Soldiers of the English Civil War (2): Calvary." London: Osprey. A popular book includes basic information and pictures involving cavalry of the English Civil War.

Wallace Collection and A. V. B. Norman (1986), *European arms and armour supplement*. London : Printed for the Trustees by Balding + Mansell Supplement dealing with European arms and armour.
Wallace Collection and Guy Francis Laking (1910), *Catalogue of the European armour and arms in the Wallace collection at Hertford House. Under the authority of the Trustees.* London, Printed for H.M. Stationery off. Catalogue of the Wallace collections European armour and arms.
Wallace Collection and J. G. Mann (1938), *General guide to the Wallace Collection. Brief guide to the arms and armour.* London : Printed for the Trustees of the Wallace Collection. A brief guide and overview to the Wallace Collection.
Wallace Collection and J. G. Mann (1945), *European arms and armour : with short descriptions, historical and critical notes and numerous illustrations.* London : Printed for the Trustees by W. Clowes and Sons, Ltd. Has descriptions, historical and critical notes and numerous illustrations from the Wallace collection.
Wilkinson, Fred. (1978) *Arms and Armour*. London: Hamlyn Publishing Group Ltd.Traces the history of armor and edged weapons in Europe from ancient times through World War II. Also includes info on armorers of the time and has pictures of famous garnitures made for kings.
Williams, Alan and Anthony de Reuck(1995), *The Royal Armoury at Greenwich, 1515-1649 : a history of its technology*. London: Trustees of the Royal Armouries. A history of the Greenwich royal armory and its technology.

Military Strategy

Barriffe, William. *Military Discipline: or the young artilleryman*. London, England: John Dawson, 1643.
Primary text of training for artilleryman

Buck, Thomas. *Directions for Musters*. Printed by Thomas Buck & Razer Daniel: Cambridge 1638
Primary text of training procedures for soldiers

Corvisier, Andrea. (1979) *Armies and Society in Europe 1495-1789*.
Bloomington:Indiana University Press.

Cruso, John. *Militarie Instructions for the Cavall'rie*. Kineton, England: The Roundwood Press, 1972 (1632).
Primary source of cavalry instructions in the 17th century

Davies, Edward. (1619) *The Art of War and English Traynings*. London: Edward Griffin.
English text from the 17th century dealing with strategy and training

De Gheyn, Jacob. (1999) *The Exercise of Armes : All 117 Engravings from the Classic 17th-Century Military Manual* London: Dover Publications.

Hall, Bert S. (2002) *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics.* Johns Hopkins University Press.
Impact of firearms on European warfare up to the mid 17th century

The English Civil War Society of America Handbook
Manual for English Civil War Society, includes several sections on military organization and strategy

Parker, Geoffrey , *The military revolution : military innovation and the rise of the west, 1500-1800* New York : Cambridge University Press, 1988.
Lecture series of military advances

Tincey, John. *Soldiers of the English Civil War (2): Cavalry*. London, England: Osprey Publishing, 1990.
Contains some tactical information of the English Civil War, as well as training and lives of the soldiers

Wagner, Eduard, (1979) *European weapons and warfare, 1618-1648* London : Octopus Books,
Text dealing with warfare techniques in the 17th Century

Weigly, Russell F. *The Age of Battles*. Indianapolis, IN: Indiana University Press, 1991.
Deals with development of battles apart from raids and siege warfare