“Forging Art and Science: The Rise of Brass Instruments in Medieval Art Music as a Result of Advancing Metallurgy”

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While sciences and the liberal arts often are seen at odds with each other, be it a “right brain” or “left brain” mentality, all too often studies in each field overlap, though sometimes not in the most obvious of methods. While at first it may seem that a Medieval blacksmith might have little to do with a Medieval musician, there can be drawn connections between the two seemingly unrelated fields of study. Often a Medieval blacksmith is stereotyped as a purveyor of death-dealing instruments of war, and the stereotyped Medieval musician contemplates the greatness of humanity. While admittedly both metallurgy and music can been seen as a form of art, were they directly impacting each other during the Middle Ages? It is curious to see at the onset of the Middle Ages metal instruments were rare; however, within 450 years, the Renaissance exhibited some particularly glorious pieces to the brass instrument repertoire. Even still, metallurgy exhibited huge advances in methods and practice during the Middle Ages, advancing from ‘hole in the ground’ furnaces to advanced iron-smelting blast furnaces. With the rise of both the technological prowess of metalworking and the rise of metal instruments, it would seem prudent to ask: Did the advances in metallurgy during the Middle Ages have an impact on the proliferation and use of metal (brass) instruments in Western Art music?

The impact of metallurgy and brass instruments during the Middle Ages has not been extensively reviewed, seemingly as a result of the low number of iconographic sources and treatises on fabrication methodology. By examining the developments in metallurgy and mining, one can discover an additional aspect with regards to the development of the

brass instruments. Unlike musical instruments such as stringed instruments, woodwinds, percussion, and the human voice, brass instruments require more advanced technology for the following reasons: 1. the principal material (various alloys of bronze and brass) is not naturally occurring; 2. metal is exponentially tougher to fashion than wood and cannot be done effectively by hand at room temperatures; and 3. the raw material (ores) can only be accessed from an exhaustive, expensive, and extremely labor-intensive mining process. For example, while a tree shaped as a lute may not exist in nature, the technology of the period, such as chisels and hammers, allowed easy manipulation of materials such as wood. Unlike wood instruments, brass instruments must be crafted through mining the raw materials then manipulating ores for the base material. The mining and refining processes exhibited great advances during the medieval period. Edmund Bowles remarked in his acceptance of the 14th century slide trumpet that music historians should note "the important role played by medieval technology in providing the means for fabricating such instruments (Bowles 350)." This statement proves an important starting point for tracing the impact on metallurgy on brass instruments. By the end of the medieval period, Europe at large experienced vast advances in the field of metallurgy, including the quantity and quality of ore, purification of metals, and metal manipulation. In addition, through the study of iconography, there was an increase in the number of metal-based instruments.

The study of the advancement and impact of metallurgy on brass instruments must first be grounded in the status of metal instrument and their use at the end of the age of Antiquity. This history of metal instruments rests first in non-metal horns and labrosomes, being lip-vibrated instruments. The technology for manipulation and

availability of such primary materials as animal horns, wood, bone, ivory, and pottery trumpet-like instruments would be readily available during this period. Curiously enough, the Egyptian mastery of metal placed their civilization far ahead of all others, with two metal trumpets being found in King Tutankhamen's tomb from dating approximately 1300 BCE (Baines 53). Such metallurgical mastery would not be found in Europe until the Middle Ages.

Iconography shows that a primary use of brass instruments dating through Antiquity back to the Egyptian pharos was primarily that of a specific military-related tool: a device used in signaling tactical troop advancements and also used to disrupt advancing enemy cavalry. As blacksmiths of medieval period were mainly known as purveyors of weapons, it is without surprise that metal instrument makers were most likely blacksmiths as these artisans were the only people of the time who possessed both the knowledge of metallurgy and the tools to fabricate a metal musical instrument (Baines 53).

It is without surprise that the primary source of study of use of brass instruments during the Middle Ages also rests in iconography. The Latin word *tuba* appears frequently throughout Christian literature in the Middle Ages of Europe. It is without surprise that musical instruments were a recognized area of study for the church, as in St. Augstine's (354-430) *De Doctrine Christiana* the importance is stressed for biblical scholars to have knowledge of musical instruments, particularly their structure (Page 303). Many eighth and ninth century illustrations included trumpets of some form, usually signaling the apocalypse as in the case of the *Trier Apocalypse*. A rather baffling document of interest would be the *Epistle to Dardanus*, wherein the letter, entitled *De Diversis Generibus Musicorum* (translated *'Concerning diverse kinds of musical*

instruments') which was questionably written by St. Jerome (c.347-420). The work outlines effectively a study guide for readers of the Old Testament, and was illustrated most likely by Hrabanus Maurus (780-856), giving additional proof of the trumpet during the early Middle Ages. While often the illustrations are considered 'fantastic' and possibly even a 'hoax' these illustrations, labeled 'as Hieronymous affirms' gives credence that the musical instruments hold true to the description presented both in the Bible and other contemporary resources (Page 302). Additionally, Isidore of Seville, considered a major authority on musical instruments during the Middle Ages (Page 300), had illustrations in the 11th century of his works, gives the collaborative resource of several conical trumpets as well. From a secular viewpoint, trumpets could have been used as early as 1060 AD, with an illustration in the Nevers Bible of a horn-blower and a dancing fiddler around a tree with neumes rising from both, possibly using the horn to gather an audience while the fiddler performs works. The nuemes are penned differently in both cases, whereas the fiddler has a series of pitches and patterns, but the horn-blower with a different pattern at a constant pitch (Baines 70).

Without question, one of the greatest resources available to iconographic discussion on brass instruments would be the Macclesfield Psalter. Within this Psalter, we see the trumpet illustrated more than any other instrument, with 9 long trumpets and 5 short trumpets, and one peculiar possible performance of two trumpets at the same time, though this final performance is unclear as to whether or not these were trumpets or some other form of wind instrument. The long trumpets are of particular significance, showing proportionally about 1.5 meters each, divided into sections with soldered ball-joints at each section. (Montagu 189). These were most likely made in a fashion of being "rolled

up, presumably on a mandrel, with a soldered overlap [ball] joint." (Montagu 190). These trumpets have been investigated thoroughly, but there is always a critical issue with iconographic sources: How does one prove that these illustrations are indeed accurate, and not simply a 'hoax' or a 'fantastic' exaggeration? Enter metallurgical archeology to help to prove or refute these illustrations.

In 1984 during a renovation project in London, a series of brass-bronze tubes were unearthed from the riverbed of the Thames. Upon further investigation, these parts were found to be an intact discovery of a Middle Ages long trumpet. Called "The Billingsgate Trumpet," archeologists and musicologists closely observed this instrument with great care to look for more insight into performance practice of brass instruments of the period of the Middle Ages (Webb 60). After undergoing very close inspection, it was found that these were indeed musical instruments of a length of approximately 1.61 meters (Webb 61), which would corroborate the illustrations of the Macclesfield Psalter. Even more intriguing was the presence of the ball-joints, as illustrated, to assist in the assembly of the instrument. However, upon closer inspection, it is now currently believed that the four parts do not make up the same instrument. The first and second sections, after a metallurgical analysis of energy-dispersive fluorescent X-rays, are made latten (copper-zinc-tin), while the third and fourth (bell sections) are made of brass (copper-zinc) (Lawson 153). This is particularly interesting to show that musical instruments were being made with both lower quality latten and higher quality brass. Speculation as to why the instrument was abandoned still plagues researchers today; however, it is safe to say it was not scrap material or a failed instrument as it shows signs of both use and soldering

patchwork and repair (Lawson 153). The use of archeological metallurgy helps to shine even more light onto the history of brass instruments.

After observing the use of both iconography and archeology to trace key points in the development of metal instruments, it would be prudent to further investigate the importance of advancing metallurgy throughout Europe during the Middle Ages. With the fall of Rome, many of the mining techniques were lost to Western Europe. The mining process was an exhaustive process, with the tools available (hammers and chisels) the mining process through hard rock could rarely exceed an average of 20 centimeters per day, relying on fire setting to fracture large bodies of rock (Raymond 98). This difficult process would invariably limit production of all metals and ores, not just copper, therefore making metals expensive and undoubtedly rare to non-military uses (Raymond 99). It was Charlemagne, however, who began the crucial reviving of mineral excavation and mining, allowing his empire access via Saxton slave-miners to vast quantities of lead, silver, gold and iron. Relocating the capital of his empire to Aachen, Charlemagne now had access to huge amounts of metal ores at his disposal from German locations, causing metallurgy to flourish in the centuries following his reign (Raymond 98-99). Curiously enough, the rise of metal instruments in musical iconography begins to appear about two centuries after Charlemagne's sweeping reforms in metallurgy, showing a rise in available resources.

The advances in mining were paralleled closely with the development of metallurgy. As stronger tools were made available, mining could be done in a more effective and efficient practice (Raymond 100). From a metallurgical approach, mining and metals in Europe at the onset of the Middle Ages were still made in the same manner

as the Romans (Tylecote 75). While each area of Europe developed at a steady pace, it was the Germans who quickly asserted their status as the masters of metal in Western Europe during the Middle Ages. Due to Germany's location with many valuable ores and mines, German monks and alchemists had access to many materials that were much rarer to the rest of Europe, particularly the mine of Rammelsberg and the town of Goslar. This mine became a "key training school for miners, prospectors, and smeltermen" (Raymond 100). As a result, the area around Rammelsberg became flooded with miners, fortune-seekers, merchants, artisans, farmers, and craftsmen (Raymond 100).

With this wealth of natural resources coupled with intellectual growth, many of Europe's brightest metallurgical minds came from Germany during the Middle Ages. While the writings of several other German monks gained notoriety as metallurgical treatises, it was Theophilus who first wrote *De Diversis Artibus* which was written around 1100AD, clearly showing both the advanced cementation research and draught-induced crucible furnace which catapulted Germany to the forefront. As a result, this process became entitled "The German Process" (Pollard/Heron 202) which reigned into the 14th and 15th centuries, utilized by other famous metalworking monks such as Albertus Magnus (1193-1280), Thomas Aquinas (1225-1274), and Roger Bacon (1214-1292). This process relied heavily on calamine, or naturally occurring meteoric zinc. This method is of particular importance to brass manufacturing (Pollard/Heron 202), as calamine had limitations to the purity of brass, as the process limited the total zinc content to 28% or less prior to 1100AD. With the higher amount of impurities, brass alloys are less malleable and cannot be thinned as effectively compared to the later use of metallic zinc (Pollard/Heron 203). Metallic zinc was first officially recognized in Europe

by the Swiss physician Paracelsus in the 1400's, though likely had been unknowingly in use in various forms in the previous century, as is shown by the excavation of various brass materials throughout Europe (Pollard/Heron 203). The advances of the German refining process had effects on all aspects of metallurgy. Moreover, the rise and prominence of craft guilds in Europe flourished in the late Middle Ages, where knowledge and advancement of the particular craft was paramount (Bowles 351). Interestingly enough, copper in its "pure" state was considered a lesser metal, as most of the interest was centered on brass and bronze, made clear by Bartolommeus Angelicus (Aitchison 321). By the end of the Middle Ages, we see a differentiation between low quality material bronze-brass alloy called 'latten,' which included higher content of impurities and calamine zinc (Aitchison 322), and higher quality alloy called 'brass,' wherein brass is more frequent as its "[use is] probably intentional as they make very satisfactory casting alloys" (Tylecote 75). By the end of the Middle Ages, brass accessories and items are common as by then they were neither precious nor scarce, therefore there would be no incentive to hoard (Aitchison 322).

The development of water-powered wheels and bloomeries (and subsequent blast furnaces) also leads to an improvement in the quality and consistency of metals. While previously metals had been hammered by hand, the use of "mechanical energy … was the foundation on which the most important metallurgical developments during the Middle Ages were based" (Aitchison 307). While the first notable application of mechanical production water-driven wheels happened in the twelfth century for fulling cloth, the use for metal hammering occurred in the early 1200's as the method was very similar. (Aitchison 307, 310). However, one of the most important developments of the use of the

water-wheel was used for driving bellows into a draught-induced furnace (Aitchison 308). These furnaces provided higher temperatures for the purification of slag and other molten metals, and coupled with water-driven bellows, could easily attain temperatures to separate metal from ore impurity (Tylecote 83). This higher level of pure metal, coupled with water-driven hammering, allowed for thinner, more consistent quality, and more malleable surfaces to be formed and shaped during the late 14th century, all desirable circumstances for the formation of tubing (Aitchison 307).

One of the final critical developments in applicable metallurgical technology as relating to brass instruments is the development of bending tubing without altering the interior bore (Bowles 350). By having the higher quality of brass alloys as describe above, the malleability allowed for the inclusion of lead manipulation. While lead manipulation is not a new technique to the late Middle Ages, it was included in many aspects of everyday life including drainage pipes, windows, and roofing material (Aitchison 318). Even still, lead manipulation was common to brass instruments, as the Billingsgate trumpet showed two forms of fairly precise lead-based soldering (Lawson 156). At this point, the brass alloys could sustain heating while being repaired (Tylecote 83), and therefore lead could be used to fill sections of the tube, then allowed to cool, then bent again under heat. This is proven in fact by the use of lead-based solder in the Billingsgate trumpet to both repair patchwork and to solder the ball joints (Lawson, Webb et al). As the lead sustains the internal bore, the pipe can bend freely while holding interior diameter. While this process now is replaced with methods such as the use of pitch or ice, lead manipulation would be a practical, cheap, and efficient method of bending brass tubing.

It is fair to say that many iterant musicians of the Middle Ages were adept at making and repairing their own instruments; however, in the case of brass instruments, this seems unlikely. References in English accounting practices and lordships show that minstrels were often given money to purchase such wind instruments, as skills, scope, and technology required to make brass instruments were highly unlikely traits of those other than trained blacksmiths (Page 45).

Now having observed the progression of brass instruments through iconography and the progression of historical metallurgy, the impact on Art Music becomes clear. While 'trumpet-like' fanfares repeating *c* and *g* have appeared in many motets well before the 15th century, allusions to trumpet calls can be made in clearly countertenor lines such as such as the 15th century motet *Tuba of Henry of Freibur*g where the lower voices are originally marked *Contratenor tubae* and *Laudate eum in sono tubae* (Baines 84). It is likely that this would be one of the first motets to clearly depict a written confirmation of instrumental use of the 'tuba,' but unfortunately the original manuscript was lost in the 19th century during a library fire (Baines 84).

With the ability to bend tubing by means of technological advances, brass instruments at the end of the Middle Ages now begin to show in folded form; often fabricated in 'S' shapes by the late fourteenth century, and standard 'folded' form shortly after 1400 (Polk 43). Slide trumpets also begin to appear in iconography, particularly in late Gothic Alta bands alongside shawms. The *minstrel de trompette* often was found with two different trumpets, the *trompette de guerre* or 'war trumpet' was the straight trumpet, seemingly used only in special occasions (Tröster 85). Along side the *trompette*

de guerre was a form of a slide trumpet, which seems to appear in iconographic sources in the 1400's (Duffin 398).

While it can be said that there is no one singular factor that attributes to the rise of the popularity of brass instruments throughout Europe in the Middle Ages, such as social or global impacts including the Crusades, the required technology for such instruments cannot be ignored as an equally important factor in the increase of the popularity of brass instruments. By observing the status of both iconography and technology at the beginning of the Middle Ages, and then comparing it to both iconography and technology of the Middle Ages, it is fair to say that advancing metallurgy did indeed have an impact on brass instruments, both through the quality of materials available and the ability to produce more advanced instruments allowing greater flexibility and use in performance. The production of slide trumpets and sackbuts, technically far more advanced, flourished in the late Middle Ages and early Renaissance. This development allows brass instruments to become major players in Art Music, as the bulk of the instrument could now be reduced and allowing longer tubing, which also allows more harmonics and more notes. Of particular note is the following quotation:

> "Technology not only creates new things but enables people to use older devices in new or better ways. Moreover, innovations or improvements in one area often take over in others: the fascinating question of technological transfer" (Bowles 351).

It must be acknowledged that musical instruments were improved and impacted in their use as the result of craftsmen finding new ways to improve an existing product, which in turn created new products within themselves by means of innovation and available technology. "The use of technology," Bowles writes, "and invention [causes] to better the

instruments operation and improve sound, in short, mechanical science in the service of art" (Bowles 351). This statement of invention could not be more relevant, as even into today it is science that allows artists more flexibility, more freedom, and more ingenuity to constantly strive to forge new science into new artistry.

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