Development of the Flute From Pre-history to Modern Days

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Abstract

A flute is a “keyed woodwind instrument consisting of a cylindrical tube which is stopped at one end, and which has a side hole over which air is blown to produce the tone”, as defined by the Merriam-Webster dictionary. Unfortunately, this definition is only true of modern flutes. The first flutes were simple pieces of bone that had been fashioned with drilled holes. These prehistoric flutes have been discovered as artifacts in many places around the world. However, through time keys were added to expand the note range of the instrument, and to improve the intonation of the notes that were played. These improvements were added slowly, but as interest in the instrument grew, so did new ideas about its technical properties. In this paper I discuss how the flute progresses through time from a simple bone to the metal-keyed instruments of today.

Keywords: music, flute, pre-historic, Egypt, Mesoamerica, bone flute, keys, intonation.

Merriam-Webster defines a “flute”, as a “keyed woodwind instrument consisting of a cylindrical tube which is stopped at one end, and which has a side hole over which air is blown to produce the tone”. This is true for the modern flute, and many of the transverse flutes that came directly before it. However, a flute did not always fit that exact definition. The addition of keys were added at the very end of the flute’s history, and the transverse style of playing appeared only shortly before that. The transverse style of playing was when the flute moved from being blown vertically like a recorder, to horizontally like how flutes are played today. Before all of these additions, and modifications to the flute, it was a much simpler instrument, with a much simpler construction. Looking back at the etymology of the word “flute”, it came from the 14th century old French word “flaut” or “flaute” possibly meaning “to blow”. Another explanation to the origins of the word come from the Latin word flatus, meaning “a blast,” or “breathing.” This would make sense, as the flute was the first known wind instrument, meaning that it was likely the only instrument that would take a “blast of breath”, to play it. The flute has been around for thousands of years. From the ancient bone flutes of forty thousand years ago, to the technical innovations of recent times, this instrument is among the oldest known in the world. The flute progressed through history slowly, with small adjustments to the construction being made gradually, and the addition of a key or two at a time.

At the dawn of humanity, there was no music. The modern descendent of the subspecies pertaining to the genus *Homo, Homo Sapiens*, began to roam the earth about 200,000 years ago. These pre-historic humans began branching out from their origin in East Africa to Europe, and Central Asia, a mere 60,000 years ago. As pre-historic humans developed the need for communication, and a sense of community, the practice of music came into existence. The exact date of the emergence of the concept of music is unknown, however it is speculated to have begun with the use of the voice. Before instruments, the voice played a primary role in communication, and likely music, assuming that pre-historic man had the cognitive ability to control the voice. The voice came around when the hyoid, a horse-shoe shaped bone in the neck of humans, changed its shape through evolution. When the hyoid’s “shape changed... our voice box moved down our throat to take up a position that allows us to talk and sing”\(^3\). This was crucial as it “allowed our distant ancestors to communicate before the invention of language”, something that is important in establishing a sense of community in a growing society\(^4\). Eventually, as the brain of the modern human progressed in cognitive ability, ancient people began to craft simple instruments from common materials, allowing for other methods of communication. One of the most readily available materials around at the time were animal bones. Since early humans thrived through the technique of hunting and gathering, there would have been leftover bones from great animals such as the mammoth, cave bears, ancient deer, and various birds. Focusing on the bones of birds, a feature of these bones are that they are naturally hollow. Because of this, ancient man, at some point around 42,000 years ago, decided to repurpose a discarded bone into a crude, prehistoric instrument. This instrument is the flute. Now, the flute likely did not start out as being made solely from discarded animal bones. More likely, their origins began with reeds, as the “musical instruments that appeared in Europe 40,000 years ago are so sophisticated that they must have evolved out of earlier artistic traditions”\(^5\). It is possible that the origin of the flute could be attributed to a much simpler explanation, such as: “An attempt to blow or suck the marrow from a broken bone. [That] gave rise to a sound that some prehistoric man interpreted as the voice of the bone itself”\(^6\). Alternatively, and even more simply, “perhaps the wind blowing across the broken ends of grove reeds generated sounds that attracted [prehistoric man’s] attention”\(^7\). Regardless of the origins of the instrument, there is proof that 42,000 years ago, by whatever means it was created, the primitive bone flute did in fact exist.

The oldest archaeological specimen of a bone flute comes from the Geissenkloesterle Cave, in Germany (Figure 1). Found next to four carvings of a human, mammoth, cave bear, and bison, it is easy to expect that this instrument was not created anytime within recent history. This bone flute, which was made out of bird bone and ivory, was found in 2012, and through the use of stratigraphy, and Electron Spin Resonance, was found to have been from around 42,000 years ago, making it the oldest surviving instrument in the world\(^8\). There were definitely flutes before it, as discussed prior, but they likely did not stand the test of time simply because of the likelihood that organic materials from so long ago would have decomposed. Only organics in the right conditions would have a chance at being preserved, and as the world was very different back then in climate than it is now, those conditions were unlikely to cause organic preservation over 42,000 years. Returning to the Geissenkloesterle flute, it has some unique features that

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\(^7\) *Ibid.*

separate it from other bone flutes that have been found. One important feature is the technique used to make the holes in the flute. Usually, when making a hole in a material destined to be a flute, it would be made vertically through the use of drilling, or pushing a tool through the instrument to create the holes. The holes on this flute are different, as they were created not vertically, but rather horizontally\(^9\). This means that instead of applying downwards pressure with a tool from above to create the holes, the maker horizontally scraped each individual hole. This feature is especially important because instead of the sound originating at the mouth hole, like on modern flutes, the sound originates at each finger hole, as each horizontally scraped hole acts as an aperture. This design makes the instrument act more so like a series of pitched whistles, than many of the other bone flutes found from around this time. Another interesting feature of the flute is the use of a bevelled mouthpiece. This bevelled mouthpiece directed the air steadily through the bone, making the instrument easier to play. This advancement is further proof that flutes did pre-exist this one, as the bevelled mouthpiece is already a refinement of what would have been flutes without bevelled mouthpieces. On top of having a bevelled mouthpiece, and horizontally scraped finger holes, the Geissenkloesterle flute also features carvings on the body of the flute. These notches are thought simply to be ornamental, as this was a common decoration found on other artifacts from this time\(^10\). Friedrich Seeberger, a pre-historian, made a replica of the Geissenkloesterle flute to see how it sounded, and played. According to Seeberger, the “tones were clear, but very quiet”\(^11\). He noted, however, that the holes in the flute were seemingly systematically placed in regards to tone\(^12\). This flute was not simply just someone haphazardly scraping holes to see what would happen when the bone was blown through, but rather this was a calculated, or at least well thought out design in the instrument. Again, another reason to speculate earlier flutes, as trial and error regarding the placement of finger holes at other intervals along the instrument would have occurred. A final feature of the flute is that the tones could be changed by blowing pressure, which allowed for variation in sound\(^13\). This allows for intonation correction, as well as the manipulation of notes. The flute itself, when played, could possibly even produce a whole tone scale like other bevelled flutes, as long as the lips are placed correctly, and the blowing pressure is accurate to the note needing to be played. Unfortunately, because the Geissenkloesterle flute is an incomplete artifact, it is impossible to be able to tell exactly what it would have sounded like, and looked like at the time. It is very possible that it would have had more holes along the rest of its body, and could have been much longer in length, allowing for a larger range of tones.

Another important archaeological discovery in Germany took place at the Hohle Fels cave. Here, prior to the discovery of the Geissenkloesterle flute in 2012, the Hohle Fels flute was the oldest known instrument in the world. Other bone flute fragments that came out of the Hohle Fels cave were dated at 35,000 years ago. However, with the flute discovered in 2008, dating techniques show that this flute is actually thought to have come from closer to 40,000 years ago, unlike the other fragments that were found earlier\(^14\). The flute is made out of Griffon vulture bone, another flute taking advantage of the hollow bones of birds (Figure 2). This flute was found to have five finger holes, and had a length of about one foot. This flute is similar to a penny whistle in appearance, as it is a long, straight, hollow, end-blown tube. In regards to tone abilities, replications have found that the flute is able to play something similar to the modern pentatonic scale\(^15\). The flute also features a unique mouth piece, different from the bevelled flute of the Geissenkloesterle cave. The Hohle Fels flute has a V-shaped mouthpiece, possibly making the flute

\(^{9}\) Ibid., 108.  
\(^{10}\) Ibid.  
\(^{11}\) Ibid., 109.  
\(^{12}\) Ibid.  
\(^{13}\) Ibid.  
\(^{15}\) Ibid.
easier to play. The sound of this flute was likely very unrefined, and coarse, simply because it is a very archaic instrument. Unfortunately, however, it is nearly impossible to test that theory, as making a completely accurate replica is near impossible for an incomplete artifact in this condition.

Flutes have likewise had a long tradition in the Far East, with probably the biggest influence in China. China, surprisingly enough, actually holds a rich, at least ten thousand year old tradition of flute music in its culture. The oldest flutes found in China come from Jiahu, in the Henan Province. This archaeological site contains a treasure trove of ancient bone flutes. Of the bone flutes that have currently been found at this site, they have an average age range between 7,000, and 9,000 years old. More importantly than the age of these flutes however, is their condition. Many bone flutes do not survive up to the point of excavation simply because they are made of a fragile material of organic composition. The flutes that were found in Jiahu, however, include artifacts of flutes that are both in poor condition, as well as some in excellent condition. Of the more than thirty flutes that have been found, there are a total of six flutes that are in such good condition, that they are considered the oldest playable instruments in the world (Figure 3). The discovery of intact neolithic flutes is a groundbreaking discovery, as replications are not necessary to test sound and playability. For the six Jiahu flutes, including one dated at 9,000 years old, sound samples, and tests can be performed directly with the existing instrument, making for accurate representations of the playability of other, similar flutes from the time. The 9,000-year old flute is made out of the ulnae bone in the wing of the red-crowned crane. The flute is about nine inches long, and has seven holes. An interesting point to make about the holes on this flute, is that the seventh hole has been altered. When observed closely, it is possible to see that the seventh hole has a second, smaller drill mark next to it, raising it from a G-Sharp, to an A (Figure 4). This extra drill mark has a lot of significance in the study of ancient instruments. Essentially, this means that the instrument was not only hand-crafted by a person 9,000 years ago, but was also tested, and then had its tuning adjusted to correct it, as well. With this adjustment to tuning, the flute has the ability to play a scale very similar to the Western eight-note scale. This information is important because it allows archaeologists to study the tonality of the music that could be played on this instrument. Rather than only having the ability to play a pentatonic scale, or some other form of scale like some of the other flutes could, this flute had the ability to play all of those notes, and more. The fact that the instrument could play a well-constructed scale is also important because it shows that unlike what is commonly thought, prehistoric culture, and more specifically prehistoric Chinese culture, was far from crude. The scale, it is also important to note, starts above the treble staff, at A, well within the range of a modern flute from today. In regards to the sound of the instrument, “Garman Harbottle, a nuclear scientist who specializes in radiocarbon dating at Brookhaven National Laboratory on New York’s Long Island”, reports that

16 Brookhaven National Laboratory, Brookhaven Lab Expert Helps Date Flute Thought to be Oldest Playable Musical Instrument: Bone flute found in China at 9,000-year-old Neolithic site (Brookhaven National Library, 22 September 1999, https://www.bnl.gov/bnlweb/pubaf/pr/1999/bnlpro92299.html).
17 Ibid.
19 Brookhaven National Laboratory, Bone Flute Found in China at 9,000-Year-Old Neolithic Site.
20 Ibid.
21 New York Times, After 9,000 Years, Oldest Playable Flute Heard Again.
22 Brookhaven National Laboratory, Bone Flute Found in China at 9,000-Year-Old Neolithic Site.
24 New York Times, After 9,000 Years, Oldest Playable Flute Heard Again.
it has “a reedy, pleasant sound; a little thin, like a recorder”\textsuperscript{25}. Even though the sound was unrefined, and thin it was pleasant, and reminiscent of a well crafted instrument that would have been come into existence at a later time. Another interesting fact about the flutes found in Jiahu is the reason for the instruments being made out of bone. Like with other bone flutes, there were flutes made out of other materials, such as reed for example. In the neolithic Chinese culture, however, emphasis was placed on making flutes out of bone instead of reed, as to make the instrument more resilient, and resistant to damage\textsuperscript{26}. The Jiahu flutes hold a very special part in the history of the flute in particular, because they are the oldest intact instruments in the world, that are still able to be played today.

By the first century BC, we witness one of the first bone instruments in the Americas. Coming out of Yugue, in pre-Columbian Mesoamerica, this bone flute is dated to around 100-250 CE\textsuperscript{27} (Figure 5). This flute is much different than the other bone flutes that were previously talked about. The flute was almost a foot long, at 25.3 cm in length, and had four holes on the front, and one hole on the back\textsuperscript{28}. This is already a difference from the other bone flutes, as all of their holes appear on only one side of the instrument, instead of some on the front, and some on the back. The hole on the back is an indication for the use of the thumb in fingerings, which was new to the instrument. Another aesthetically different change between this, and the previous bone flutes is the addition of intricate carvings on the body of the flute (Figure 6). The flute has carvings of two figures, one seeming to represent a skeleton, and the other just a human face wearing a mask. The carving of the skeleton is accompanied by a “volute”, also known as a “speech scroll”. Speech scrolls were “a widely used means of depicting the movement of air in the pre-Columbian art of Mesoamerica, particularly speech, wind, music, song, breath, and scent”\textsuperscript{29}. In this case, the volute is likely representing speech, or music. The skeletal carving is “positioned so that the depiction of its breath or voice is being projected toward the bell of the flute, which is the end from which the musical instrument produced sound”\textsuperscript{30}. Because of this positioning, the sound would have appeared to emanate from the mouth of the carving. The positioning of the head in the carving is also important to note, because it is positioned so that the fourth finger hole lines up with the anatomically correct position of an eye hole. The reason for the addition of a carving of a skeleton in the body of the flute can only be speculated. For example, the skeleton could have been a reference to the significance of death, or even just a reference to the deer bone that the flute was crafted from. The other carving, the one of the masked face, is attached to the volute of the skeletal carving. This figure of a masked human face is particularly unique because of its speculated relationship to important gods in the Oaxaca society. The figure wears a long, beaked mask that features fangs over the mouth and chin. The mask is known as a “Buccal mask in Mesoamerican iconography, [and is] consistently associated with rain and wind divinities in the pre-Columbian era”\textsuperscript{31}. Archaeologists have speculated that the etchings on the flute represented the voice of the gods\textsuperscript{32}. The “voice of the instrument makes manifest a second entity who is probably an ancestor impersonating a Mesoamerican rain or wind divinity”\textsuperscript{33}. This carving also has a volute extending from its mouth. The flutes in the Yugue society likely held an important role in summoning gods from the sky to the human world for use in rituals. This type of musical association was also apparent in the rituals of other ancient mesoamerican societies, such as the Aztecs, who would use

\textsuperscript{25} \textit{CBS News}, A 9,000 Year Old Tune.
\textsuperscript{26} \textit{Ibid}.
\textsuperscript{28} \textit{Ibid}., 99.
\textsuperscript{29} \textit{Ibid}., 100.
\textsuperscript{30} \textit{Ibid}.
\textsuperscript{31} \textit{Ibid}., 99.
\textsuperscript{32} \textit{Ibid}., 100.
\textsuperscript{33} \textit{Ibid}., 101.
trumpets to summon gods during human sacrifices. The discovery of this flute was also important because for the first time, a flute was found with other funerary objects in a grave. This flute was located in the grave of a young boy who died when he was only between fifteen, and seventeen years old. This boy was likely of higher status because of a lack of physical evidence of physical labour, and because he was buried with a clay pot, and an imported pyrite mirror. The boy died of unknown causes. However, it is likely that the boy played the flute while he was alive, because it was positioned in the grave as if it was being played. The fingers of the boy were placed curved around the bell of the instrument, with the finger holes facing away from the body, and the instrument resting against his left forearm. Unfortunately, it is impossible to replicate the sound of this flute, because it was made using the bones of a deer from 2,000 years ago, and a modern deer bone, even with similar measurements, would not have the same internal bore as that of the Yugue flute. It was also found in a very poor state, with fractures separating the bone into upwards of fifty pieces, and was coated in a layer of crystallized salts beneath the bone’s outer surface. Regardless of the condition that the flute was found in, it was likely a very important item in the Yugue society, and would have been crafted, and played, by someone who possessed a very valuable, musical skill.

There are various theories about the importance of the flute in early societies. One theory is that because these flutes are often found in sites with other artistic means of expression, including Venus figurines, and cave paintings, it is possible that the making of instruments was just another way that early humans began showing a sense of self-expression. This is important because these paintings, and carvings came around as the beginnings of human cultures, differentiating the Homo Sapiens subspecies from other hominins of the time. Another theory about the importance of the flute in early cultures is that the creation of instruments were important because of their role in the making, and tightening of bonds in communities, and groups. Since listening to, and playing music is a way of bonding with the people around you, it is very possible that it worked in a similar way in older societies. Music would have likely been used in a ceremonial context, for dancing, and perhaps even for entertainment purposes. An old story from China even tells of a hunter using a reed flute to attract birds when hunting. So, ancient flutes could have been made, and used as a tool for luring prey to hunters. However, more likely, ancient flutes were made for many reasons, as the proof for a singular reason of production has yet to be found.

In the ancient society of ancient Egypt, flutes appeared as a common instrument. Unfortunately, very little is known about flutes of this time period. One specimen, however, comes from an archaeological excavation in 1890. An archaeologist, Mr. Flinders Petrie, had been asked by Thomas Lea Southgate, someone who was studying the rise of musical notation, to look for any signs of music notation in the area he was excavating. Petrie, however, came across something else entirely, a pair of ancient Egyptian double-flutes buried in a 3,000 year old tomb with the body of Lady Maket. These double flutes were each “About sixteen inches long and three-sixteenths of an inch diameter,” with four finger holes on one, and three on the other. Many of the ancient flutes recovered from Egypt had either three, or four finger holes, which means that three, or four holes was likely a common feature of the flutes. The bores of these flutes were incredibly small, with

34 Ibid.
35 Ibid., 96.
36 Ibid.
37 Ibid., 98.
39 Ibid., 18.
Southgate stating that he “felt that such slender tubes as these would not have spoken as flutes\textsuperscript{40}.” These flutes likely used some sort of reed mouthpiece, as it was hard to direct large amounts of air into such a tube of such small diameter. Southgate tested the possible sound of the double-flute three ways. The first was by lip blowing, the second was by using a small straw reed, and the third by using a small, tenor bagpipe reed. The first method, the lip-blowing, yielded the notes F#, G, A, Bb on the three holed pipe, and F#, A, Bb, C, and D, on the four holed pipe. The fundamental note for the two tubes is the F\#\textsuperscript{41}. Using a small straw reed, Eb, F, G, Ab, and Eb, G, Ab, Bb, Cb, respectively. Because the reeds obey the law of acoustics, the notes are “Down an octave lower, and about one tone father, to agree with the additional length the short piece of straw added to the tube\textsuperscript{42}.” The bagpipe reeds were unfortunately found to be too strong, and resulted in the pitch being lowered further by a minor third\textsuperscript{43}. The results of this test found that “By varying the wind pressure, obtains from the three-hole pipe the complete diatonic scale of C,” meaning that with practise, an instrumentalist could have easily manipulated the instrument in this way\textsuperscript{44}. The flutes were also not likely both played at the same time, but rather one likely acted simply as a drone, played under the melody of the other. It is possible that the flutes would have been played in a quivering between the two pipes, as a possible beginning of the tremolo\textsuperscript{45}. The pipes were also stopped by the second joints of the fingers, rather than the first\textsuperscript{46}. The pipes were blown in an inverted V-shape, as depicted in a fresco from another tomb, Beni Hassan\textsuperscript{47} (Figure 7). This fresco depicts “a lady playing the double-flutes, accompanied by some others, clapping their hands to the dancing of two Nubian girls”\textsuperscript{48}. The depiction of dancing, and clapping shows the flute in what is likely a casual setting, with the purpose of entertainment in honour of the god Ptah, the god of craftsmen, and architects. The Egyptians called the pipes “Mam”, supposedly with Phoenician origins\textsuperscript{49}. They were also present in Greek culture as Tibia pares, and Tibia impares, depending on whether the tubes were the same length or not. The holes on the pipes were not haphazardly placed, but rather the tuning was regulated. As for their significance, the flutes were likely played by Lady Maket as a form of entertainment, as well as in ceremonies.

The flutes of ancient Greece were less common than that of ancient Egypt. Not very much has been uncovered about flutes from this time. The flute was not overly popular, with the aulos, a double-reed instrument with two pipes, as the flutes main competition. The aulos is often called a 'Flute,' though it does not technically match the definition of a flute, and is much more similar to an oboe. The transverse aulos, however, was closer to a flute, than the regular aulos was. The transverse aulos was a single pipe of the flute type, that was held sideways, like a modern flute\textsuperscript{50}. This flute was only in use in a pastoral environment. It was used by shepherds, and herders, as an instrument of the common folk. The flute does not appear in Greek art, or literature until the Hellenistic period\textsuperscript{51}. Greek instruments tended to remain simple. The flutes were not a large part of ancient Greek life.

\textsuperscript{40} Ibid., 13.
\textsuperscript{41} Ibid., 22.
\textsuperscript{42} Ibid., 24.
\textsuperscript{43} Ibid.
\textsuperscript{44} Ibid., 25.
\textsuperscript{45} Ibid., 27.
\textsuperscript{46} Ibid., 26.
\textsuperscript{47} Ibid., 19.
\textsuperscript{48} Ibid., 18.
\textsuperscript{49} Ibid., 20.
\textsuperscript{51} Ibid.
For the ancient Romans, however, the flute played a more central role in their society. The Romans called reed-pipes the “Phoenecian pipes”⁵². For the ancient Romans, the pipes stood for the ideal of the god Dionysus. Dionysus is the god of the irrational, and chaos, making the pipes stand for just that. The pipes were also associated with ecstasy, and inebriation⁵³. A coin from Caesarea, in Syria, is stamped with a picture of a flute, meaning that by the 2nd Century, Rome had for sure been acquainted by the flute⁵⁴. This coin features an image of a transverse flute (Figure 8). Another artifact from around the time of ancient Rome that portrays a flute comes from an Etruscan tomb. When this tomb was excavated, an urn was found. This urn had on it a relief carving of a person playing a transverse flute⁵⁵ (Figure 9). More importantly, this carving showed a flute that was held horizontally, and to the right like a modern flute, with the fingers of the player stopping the holes, and a mouth hole one-quarter of the way along the tube. This urn is likely the first portrayal of a true transverse flute. Unfortunately, there is not too much information on flutes in Roman societies, though their appearance in art show some importance.

There are no flutes from the medieval time period that have survived to today. Unfortunately, the only information that has been gained about medieval flutes comes from art. Though there are no surviving instruments, they do appear often in art. What is especially unfortunate about the lack of flutes from the time, is that there is no possible way to investigate the structure, or sound of the instrument⁵⁶. Unfortunately, no music from the time period has seem to have been written for the flute, either, so the potential range of the instrument is unknown. The flutes, however, judging by the art of the time, were however, held sideways to the left (Figure 10). The flutes had no keys, but likely had six finger holes, and would have been constructed out of a single piece of wood, or bone⁵⁷. The flute likely had use in mostly sacred settings, though use in social settings as well, was probable. Unfortunately, there is no indication on the depictions of flute players as to what kind of music was being played, so their use is only speculated. The majority of medieval iconography depicts the flute in a pastoral setting, often with characters from pagan mythology⁵⁸. This likely means that the flute was more often used in regards to a religious setting, than otherwise. The flute’s importance in regards to the association with pagan mythology is unknown. Other art from the time depicts flutes as used by shepherds, following the theme from earlier times that it was likely a common instrument for herders⁵⁹. Another possible function for the flute in medieval times was the use of the instrument in hunting. Apparently, deer like the sound of the medieval flute, whatever that happened to sound like. Flutes were also used in a military context, contributing to the rise in popularity of the instrument⁶⁰. Unfortunately, the flutes of the medieval era remain in mystery.

During the renaissance interest in the flute intensified. The interest in the flute was sparked by its use in a military setting, particularly by the Swiss army. The Swiss army was of interest because of its use of the fife, another kind of flute in the flute family, and its importance in their military music⁶¹. The renaissance also brings forth the earliest mention of a flute in a treatise, coming from Martin Agricola’s Musica Instrumentalis Deudsch, in 1529⁶². This suggested

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⁵² Phillip Bate, The Flute, 60.
⁵³ Ibid., 61.
⁵⁴ Ibid., 62.
⁵⁵ Ibid.
⁵⁶ Anna J. Reisenweaver, The Development of the Flute as a Solo Instrument from the Medieval to the Baroque Era (Musical Offerings, Cedarville University, http://digitalcommons.cedarville.edu/musicalofferings/vol2/iss1/2/, 2011), 12.
⁵⁷ Ibid.
⁵⁸ Ibid.
⁵⁹ Ibid.
⁶⁰ Ibid.
⁶¹ Ibid., 13.
⁶² Ibid.
that the flute had two main uses, in the military, and in chamber music. The flutes from the early renaissance had six finger holes which were spaced in two groups of three, with a body crafted out of a singular tube. This configuration of holes allowed for the player to choose which hand was closest to the mouth hole. Players chose either to place their left, or right hand closer to the mouth hole, though usually the instrument was held to the right. There were three main sizes of flutes; Bass, tenor/altus, and descant. These were similar to the configuration of the four voices in a choir. Flute makers would usually make all three sizes of flutes, and sell them in sets for proper relative tuning between the instruments. Flutes of this time typically had a range of fifteen to sixteen notes, and sounded an octave higher than written, similar to how a piccolo sounds today. The instruments, however, were surprisingly large, suggesting a flat pitch. The original pitch suggestion is that the Bass flute was in G, the tenor/altus was in D, and the descant was in A, however, because of this large size of instrument, it is more likely that the instruments would have been in F, C, and G respectively. The earliest surviving music for flutes is to be found in Attaingnant’s two chanson collections of 1533 which mark off most of the pieces contained in them by the letter A to indicate the use of flutes and B”, for recorders, a more popular wind instrument of the time. Most of the pieces, however, are actually marked by both, and could be played by either instrument. Interestingly enough, the pieces marked for recorder only are the pieces that do not contain a flat in the key signature, possibly meaning that it would have been more practical to have recorders play pieces without flats, as the flute may have issues with playing in flat keys. These pieces would have required all three types of flutes, as “a consort of alto, two tenors and bass are intended”. The largest surviving group of renaissance flutes comes from the Academia Filarmonica in Verona. This large collection of flutes allows for the study of the sound, and mechanics of the flutes. One notable point of interest is that most of the flutes were tuned to a pitch of A450, but two of the French flutes in the collection were rather tuned to A410 instead, which was common in France. This French tuning is almost a whole tone below the tuning in other places such as Italy. The descant flute is most commonly found to be played in a range up to G”, mostly revolving around a range of F”-D”. This is the range that would have been most resonant, with the best tone quality, and projection. It is to be noted that the bottom notes of the flutes would have rarely been played, as they would have been soft, and would not have resonated well. The renaissance flutes would have given “their high notes quite effortlessly without getting too loud or shrill”, an important quality in an instrument that plays in a higher range than most others. The bores of the tenor flutes range from 17.5 to 18 mm, and the basses from 24.5 to 25 mm, fairly large for a flute. The mouth hole of the tenor flutes tended to be somewhere between 8, and 8.8 mm. This mouth hole was especially small, considering the size of the bore. Flautists

63 Ibid.
64 Ibid.
65 Ibid.
66 Ibid.
67 Ibid.
68 Ibid., 4.
69 Ibid., 5.
70 Ibid.
71 Ibid.
72 Ibid., 6.
73 Ibid.
74 Ibid., 8.
75 Ibid.
76 Ibid.
77 Ibid.
78 Ibid.
79 Ibid.
from the time would have likely also doubled on the recorder, with the ability to easily switch back and forth between the two instruments.

By the early 1600’s, the flute began progressing much quicker than it had in the past. In the past, technological advancements of the instrument would happen over long periods of times, ranging from hundreds to thousands of years. In the 1600’s, the flute began to progress much more rapidly, with multiple improvements made every century since the 17th century. Prior to the early 17th century, flutes were manufactured as a cylindrical, one, or two-piece instrument. In the early 1600’s, however, we see rise of a three-piece instrument, consisting of a headjoint, body, and footjoint, just like the modern flute78 (Figure 5.1). This change in the number of pieces of the body of the flute was important, as it allowed for easier transportation by breaking the instrument down into smaller parts, as well as it added to the ability to adjust the instrument during setup. When setting up a single-piece instrument, there are no options to adjust the alignment of the footjoint, or headjoint, as the instrument remains as is, in a single piece. With a two-piece flute, containing a body, and a headjoint, the position of the headjoint could be determined by the player when setting up. Similar to the two-piece flute, the three-piece flute allowed for even further personal adjustment because the player could now not only adjust the headjoint to their particular preference, but they could adjust the position of the footjoint as well, allowing for an instrument that could be readjusted to each player’s specifications. This ability to transport, and adjust the instrument with more ease allowed for the instrument to gain more popularity as an accessible instrument to more people. Another feature of the flute from the early 1600’s was a modification of the headjoint. Now, the headjoint contained a singular key to be played by the player’s right pinky finger. (Figure 11) When pressed, the added key on the footjoint would allow for a new note to be played, this note is an Eb79. Previously, the note Eb was unobtainable on the flute, and would not be possible to play, making the instrument obsolete for any music in keys that were flat. This note was especially important, as it now allowed flutists to play a fully chromatic scale over two, and a half octaves80. This ability to play a fully chromatic scale was also an important feature on its own, as music from the time was slowly moving away from the use of modes in composition, to the use of major, and minor tonalities when composing81. An instrument that has the ability to play in all flat, and sharp keys has a higher chance of becoming a commonplace instrument, one that is commonly written for, and used. The flute of the early 17th Century also featured a set number of finger holes. Previous instruments, such as the neolithic bone flute, would have a wide range of number of holes for their flutes. By the 1600’s, the accepted number was a standard six holes, which allowed for ease of finger positioning, and playability, with three fingers on each hand covering the six holes82. Another change in the manufacture of the flute was the introduction of a tapered bore down the centre of the instrument. Instead of having a cylindrical hole down the centre, the flute was crafted with a tapered bore. This tapered bore allowed for “closer spacing of the finger holes, and improved intonation”, correcting some of the intonation issues of previous flutes83. In regards to the sound, and playability of the 1600’s flute, it was most resonant when played in the key of D major, and closely related keys84. Though the flute was now able to play an Eb, the instrument was still mostly used in music with sharp tonalities, such as the B major Aria in Clerambault’s Orphee, which was actually written for this

79 Ibid.
80 Ibid.
81 Ibid.
82 Ibid.
83 Ibid.
84 Ibid.
one-keyed flute\textsuperscript{85} (Figure 12). Other pieces written specifically for the one-keyed flute were some E minor works by Bach, and more importantly, E minor works by Hotteterre.

The Hotteterre family is considered a controversial family in regards to the history of the flute. Jean Hotteterre, and his two sons, Martin, and Jean aine, were esteemed flute makers from France\textsuperscript{86}. The most influential member of the Hotteterre family was not Jean or his sons, but rather his nephew, Jacques. Jacques, so named “Le Romain”, because he spent a period of time studying music in Rome, was influential because he brought the flutes made by the Hottettere family from France to England, to show them off\textsuperscript{87}. This move from France to England was important because it is possible that Jacques Hotteterre was the one who introduced French woodwinds to England. French instruments began being used in England since around 1675, and lasted through well into the 18\textsuperscript{th} Century\textsuperscript{88}. After this introduction of instruments from France to England, an abundance of English brands including Stanesbys, and Bressan, two flute manufacturers of the time, suddenly began to resemble the instruments manufactured by the Hotteterre woodwind makers\textsuperscript{89}. This resemblance means that instruments between England, and France were slowly starting to become manufactured in the same style, in a similar way, creating one of the first standardized models of flute.

Starting into the controversial topic of the Hotteterre family, the Hotteterre’s are possibly attributed to the creation of the three-piece flute mentioned previously\textsuperscript{90}. It is unknown whether or not the Hotteterre family introduced the idea of the three-piece flute to Europe or not, but it is possible because the three-piece flute appeared during the time when Martin Hotteterre was actively making instruments. Martin made many improvements on the design of other instruments, including the musette, which showed his skill as a maker, and innovator of instruments. Through the interest in the transverse flute by Jacques, and the influence he had on Martin, it is thought to be possible that the innovation of the three-piece flute would have come around because Martin was seeking to improve other woodwinds of the time\textsuperscript{91}. Now, this is where the speculation about the Hotteterre family’s contribution to the history of the flute comes in. With multiple people from the Hotteterre family being renowned makers of the instrument, there should be multiple pieces of evidence pointing to an improvement made by the family. Looking at Jacques specifically, and more specifically what was documented when he married his wife, as their marriage contract contained an inventory of his belongings since his parents were deceased by the time of his marriage, an important piece of information is that his possessions did contain many instruments, but did not contain any flutes\textsuperscript{92}. Why would a flute maker, and possibly someone who had such interest in transverse flutes, and their possibility for technological improvements not have any available flutes? It is unknown, but this bit of information is definitely a cause for speculation about the family. Another interesting point to make when looking at the inventory of Jacques personal library, is that he did not only not have any flutes at the time of his marriage, but his personal library also did not contain any works for flute\textsuperscript{93}. Even more suspicious than not having any flutes in his personal stock of instruments, why would someone who was actively making, and playing flutes, not have any music written for the flute in their personal library? Something about the situation does not add up, as any other flute maker from the time

\begin{itemize}
\item \textsuperscript{85} \textit{Ibid.}
\item \textsuperscript{86} Tula Giannini, Jacques Hotteterre, and his Father Martin: A Re-Examination Based on Recently Found Documents (Oxford University Press, \textit{Early Music}, Volume 21, No. 3, 1993), 377.
\item \textsuperscript{87} \textit{Ibid.}, 379.
\item \textsuperscript{88} \textit{Ibid.}
\item \textsuperscript{89} \textit{Ibid.}
\item \textsuperscript{90} \textit{Ibid.}, 380.
\item \textsuperscript{91} \textit{Ibid.}, 381.
\item \textsuperscript{92} \textit{Ibid.}, 382.
\item \textsuperscript{93} \textit{Ibid.}, 383.
\end{itemize}
would be writing for the instrument, or at least own some music that was written for the instrument. One of the Hotteterre’s potential customers, von Uffenbach, specifically recorded this entry in his diary: “He [Jacques] led me into a tidy room and showed me there many beautiful transverse flutes that he himself makes and from which he wishes to gain a special profit”, so Jacques must have been making flutes, though the historical documents that have thus far been found point against it⁹⁴. What is more likely, however, to explain the lack of documentation of Jacques specifically in regards to the lack of supporting evidence in his making of flutes, is the possibility that Jacques did not work on his own in his own shop, but rather he worked with his father in his shop. This would mean that Jacques’ instruments would have been part of Martin’s inventory. The shop closed after Martin’s death in 1720, and all of the remaining flutes would have likely been liquidated, leaving no trace of Jacques’ contribution outside of the shop⁹⁵. Alternatively, the Hotteterre family did have one definite contribution to the history of the flute. In 1707, Jacques wrote a book on flute method, and it contained possible alternate fingerings, most notably for the fingering of F#⁹⁶. The idea of alternate fingerings were important because they allowed players ease in passages where using the regular fingering would create complications, or make the passage too technically challenging. Alternate fingerings gave relief to the musician, allowing for a note similar in tone, and quality to be played, while making tough passages a little bit easier. Another definite contribution of the Hotteterre family is that they did, in fact, make many high-end woodwinds, including flutes. The flutes that have currently been recovered with a mark of “Hotteterre”, however, have questionable authenticity, and are possibly just replicas, rather than the actual, historical instruments. There have been eight flutes found with this “Hotteterre”, mark that have been accredited to the family as makers. These flutes were found in places such as Berlin, St. Petersburg, and Graz⁹⁷. Of these flutes, two are “documented replicas, and two commonly have been assumed to be copies made in the last century”, as well as another two of the instruments, the ones in “Berlin and St. Petersburg, are also not original”⁹⁸. The remaining two flutes could be authentic, but that does not leave many examples of the Hotteterre flutes available for study.

Another important contributor to the developing history of the 17th century flute was Johann J. Quantz. Quantz was not only a maker of flutes, but also played the instrument, and composed multiple works. These works included a total of 121 sonatas, and 4 concertos written specifically for his model of flute⁹⁹. Quantz, building on the three-piece, one-keyed flute of the Hotteterre era in flute construction, added a second key on the footjoint¹⁰⁰ (Figure 13). This key did not add another note to the instrument, but rather it was used as another way to play Eb/D#. Both of these keys when pressed independently, played an Eb/D#. The difference, however, is that the tuning was slightly different between the two, allowing for the note to be tuned by the player, while they were playing the instrument. The holes underneath the two keys were of different sizes, one larger to raise the pitch, and one smaller to lower it. By having two holes of varying size, the flute used enharmonic distinctions in which flats were to be played lower than sharps¹⁰¹. This ability to tune to each individual situation was especially important when playing with other instruments. On previous flutes, the Eb/D# was hard to tune when it was part of a third, or a fifth, with another instrument. This addition of a key to precisely tune, and adjust intonation while the

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⁹⁴ Ibid., 384.
⁹⁵ Ibid.
⁹⁶ Ibid., 383.
⁹⁸ Ibid.
¹⁰⁰ Ibid., 3.
player was playing, allowed for closer just-intonation on these harmonics. The adjusted intonation suddenly opened up more uses for the flute as an instrument available to be used in chamber groups where tuning between the instruments was especially important, rather than only thriving as a solo instrument.

Unfortunately, however, when Quantz revealed his design to the musicians of the time, he was criticized, and his design was far from well received. His design was never accepted as an appropriate advancement of the flute. This lack of acceptance by the musical community was because his invention was seen as complex, and impractical. Alternatively, he also experimented with other aspects of the design of the flute which were better received by musicians. For instance, Quantz experimented with the shape of the mouth hole on the headjoint of the flute. At this point in time, the flute had a perfectly circular hole to which the musician would blow across. Quantz, however, decided to experiment with other shapes of opening, eventually deciding on an oval as the most appropriate shape for the mouth hole. This is the shape most resembling the shape of the mouth hole in use on the modern flutes of today. He also “undercut the tone holes, and embouchure, giving the flutes the effect of a thinner wall, and improving their response”.

Quantz’s flutes were not tuned like other flutes of the time. He felt that the other models of flutes from the time had an F that was too sharp, so on his flute, he tuned it lower than normal. By tuning the F lower than other flutes of the time, the note blended more with the other notes around it, rather than being predominantly sharp, causing intonation issues when being played. To fix another note issue, this time with the F#, Quantz offered an alternate fingering for “use when the note does not serve as the third of the chord.” Another of Quantz’s innovations is his experimentation with many different materials. The flutes of the early 1700’s, and before were made out of wood. Quantz’s flutes, however, were made out of various imported “hardwoods, including boxwood, ebony, kingwood, lignum sanctum, and granadilla.” Since Quantz was trying to manufacture quality flutes, he tried to figure out which would produced the best sound. He decided that “boxwood was the most common and durable wood for transverse flutes.” Ebony, he stated, however, produced “the clearest and most beautiful tone.” Quantz personally preferred the sound of his ebony flutes, over all other materials. The next advancement he made in the construction of the flute was the addition of a screw stopper, and tuning slide on the headjoint in 1752 (Figure 6.2). The addition of the tuning slide advanced the three-piece transverse, to now a five piece flute, with the ability of instant pitch flexibility. Again, these improvements were made with the intention of improving intonation. Though the tuning slide did not end up being passed onto the next generation of flutes, the screw stopper did, and is still used in the modern flutes of today. A special feature of Quantz’s flutes in particular is the size of the internal bore. With an internal bore “varying from 20.2 to 20.6 mm, compared with other transverse flutes, with diameters ranging from 18.6 mm to 19.9 mm”, the large bore of the Quantz flute produced a very dynamic lower register. He strived for excellence

103 *Ibid*.
106 *Ibid*.
108 *Ibid*.
110 Mary Oleskiewica, *The Flutes of Quantz: Their Construction, and Performance Practice*, 213
112 *Ibid*.
in the lower register because he felt that the flute should mimic the contralto voice, which is in a range similar to that of the lower octave of the flute. By widening the internal bore, he achieved the range of sound that he wanted. The tone of his flute was the achieved, “full, thick, and masculine.”

As mentioned earlier, Johann J. Quantz was not only a maker of flutes, but also a composer of flute music. His flute music in particular was written specifically for his model of flute. Most of the music is written in the lower range of the flute, reminiscent of the contralto voice that he wished to imitate with his large internal bore. His music was also written specifically for his two-keyed flute, and puts to use many Eb’s, and D♯’s, accordingly (Figure 14). In 1752, Quantz wrote a method book on playing the flute, named Versuch Einer Anweisung die Flote Transveriere zu Spielen, or Essay of a Method for Playing the Transverse Flute. This treatise was dedicated to King Frederick the Great of Prussia, and was released in both German, and French. This method was the most detailed, and widely respected flute method, and performance techniques, and practices at the time. The book detailed information specifically to flautists, but also contained “detailed information about music in the mid-18th century that is of general interest to all musicians.” This information covered important musical topics such as dedicating yourself to music, practise techniques, “breathing, good execution, ornamentation, extempore variations on simple intervals, cadenzas, performing in public, and accompanying.” All of these topics covered in a single, concise book, made Quantz’s methods a commonly referred to book in the 1700’s, and later. Even today, the Versuch Einer Anweisung die Flote Transveriere zu Spielen is of good use to both professional, and amateur musicians, regardless of what instrument they play.

An important topic to cover when discussing Johann J. Quantz, is his relation to Frederick the Great, of Prussia. It was already mentioned that Quantz’s Versuch Einer Anweisung die Flote Transveriere zu Spielen was dedicated to Frederick the great, but it was not discussed why. Frederick the Great was an amateur musician, and flautist himself, and because of this he hired Quantz to make, and tune flutes for him, staring in 1741. Quantz also provided his royal employer with lessons. Frederick the Great would pay Quantz 100 ducats per flute that was made for him, and in return he would import the various kinds of hardwood that Quantz needed to make the flutes for him. Frederick had a large, personal collection of flutes made by Quantz. These flutes were made of various materials, as mentioned earlier. The most common material, and the one which was only allowed to be used for flutes made for the king, was of course, ebony. Since ebony had the nicest tone, Johann J. Quantz was only permitted to manufacture flutes with ebony that were made for the king. Frederick the Great’s collection also contained multiple glass flutes, and even a flute made from amber. The flutes in Frederick’s collection were not marked the same way as Quantz’s flutes. Quantz’s flutes were marked with roman numerals, and were not signed, which is odd to not have the maker sign the instrument. This lack of a signature, however, could have simply been the wish of the king, to which Quantz had to obey. Quantz worked closely with king Frederick the Great until his death in 1773. Because he was employed by king Frederick the Great for over thirty years, and because Frederick the Great held such a large collection of instruments made by Quantz, it is easy to accurately track the improvements in manufacturing technology of the flute.

115 Ibid.
118 Ibid.
119 Ibid.
120 Ibid.
121 Ibid.
122 Ibid.
123 Ibid.
By Quantz’s death in 1773, the flute was already undergoing a new set of transformations, following closely in the footsteps that he had made while alive. Quantz had a flute with two keys, and by the late 1700’s, additional keys were added (Figure 15). The keys that were added to the flute were a closed Bb, F, G#, and C. The general construction of flutes remained the same, with six finger-holes, but the amount of keys suddenly increased from two, to five completely different notes. The addition of these four new keys was to help with the tone, and quality of the notes. Bb, F, G#, and C before were possible problematic notes, but the addition of the four added keys allowed all notes to be produced with equal tone. The addition of these keys was also important for another reason; adding the four keys eliminated forked fingerings for the usual problematic notes. The elimination of forked fingerings was important because they were often awkward, and not practical for tough, or quick passages. The addition of four extra keys made the flute became to play. Initially, flute players used a mix of baroque flute fingerings, and keyed fingerings, making use of the new additional keys.

Unfortunately, however, though the new keys helped with tougher passages, there were some downfalls in the key mechanisms. For example, if a passage in a piece of music had a D, or an Eb, followed by an F, it could not be played. This trouble with an F in relation to a D, or Eb is caused by the placement of the ring finger. The ring finger controlled both the sixth hole, necessary for D, and Eb, as well as the F key, making it nearly impossible to switch between them smoothly. To remedy this trouble, a duplicate F hole was added, though that caused other problems. This duplicate key allowed an F to be played when adjacent to a D, or an Eb, but did not allow an F to be played when it was written next to an Ab, or G#. Unfortunately, these two fingerings meant that the player would have to alternate between the F key, and the duplicate F hole, when playing a piece. Not all flutes had the same amount of keys. Usual combinations include a flute with four keys (Eb, F, G#, Bb.), six keys (Eb, short F, long F, G#, Bb, long C.), six keys, (Eb, short F, G#, Bb, low C, low C#.), and eight keys (Eb, short F, long F, G#, Bb, long C, low C, low C#.) The most intricate flute was of course the flute with eight keys, but players often preferred simpler key mechanisms, as many composers composed with simple system flutes in mind. Composers were writing for simple flutes which were capable for playing what was needed, rather than writing for the small amount of eight-keyed flutes that were being manufactured. Flute manufacturers often manufactured both single-key, and multi-keyed flutes at the same time, rather than focusing on one or the other. Most of the manufacturers that made multi-keyed flutes, were in England. Multi-keyed flutes took longer to come to France. French flutes in particular made use of narrower bores, which helped with facilitating the higher register. Increasing the ease of use of the higher register for the flute remained an increasing trend.

In 1830, Theobald Boehm released a prototype for a new flute. This new flute was the first modern orchestral flute. This flute featured a series of keys, and rings, set on a series of axles (Figure 16). These keys, and rings controlled the opening, and closing of the tone holes. As one key was closed by a finger, another key was activated further down on the instrument, via an axle. This was the first time that the flute had a key system where when one key was pressed, it directly affected the movement of another key, somewhere else on the instrument. The keys also allowed for the placement of the finger holes to be representative of where they are needed.

125 Ibid.
126 Ibid.
127 Ibid., 21.
128 Ibid., 24.
129 Ibid.
130 The Editors of Encyclopedia Brittanica, Theobald Boehm (*Encyclopedia Brittanica, 1998*).
acoustically\textsuperscript{131}. The tone holes were also made as large as necessary for tuning, regardless of the hand size of the player\textsuperscript{132}. Before, the finger holes had to be small enough to be covered by any player's fingers, rather than manufacturing with appropriate sized tone holes to help with intonation. Boehm's flute was widely accepted in France, and England, but with hesitation in Germany, was accepted later. This system of keys, and rings, is the beginnings of the key system that is still in use today by modern flutes.

Reworked, and refined, Boehm's second model of his flute was revealed in 1832. Boehm “became increasingly aware that the tone holes [on his flute] were placed incorrectly”\textsuperscript{133}. He decided to completely rework his previous fingering system (Figure 17). First, he experimented with the placement, and sizes of the flute’s tone holes\textsuperscript{134}. By progressively cutting the end of a wooden tube of the same diameter as a flute, he figured out the exact lengths that the air had to travel to make the intonation on his flute perfect. Unfortunately, when he put this method into practice, the notes were flat, so he “moved the holes back towards the headjoint”\textsuperscript{135}. Later experimentation revealed that his first two octaves were in tune but due to the holes all being of equal size, the third octave was suddenly out of tune\textsuperscript{136}. He corrected this by changing the sizes of the holes to correct the intonation. Unfortunately, this meant that “the holes were too large and too many for the fingers to cover”, so Boehm came up with a key system to cover them\textsuperscript{137}. The keys on the right hand were similar to his previous model, but the key system for the left hand was changed a lot. For instance, he removed the A key, and “brought the other holes lower so the left hand third finger could reach the A hole”\textsuperscript{138}. Boehm also added a key to cover the C# hole, moved the Bb key inline with the other keys, and moved the C hole to the inner side of the tube\textsuperscript{139}. He also added two trill keys to the flute, improving the trills for B/C, and C#/D. In 1833 Boehm introduced his flute in various cities across Europe, to which he was generally well received. There was, however, some discouragement because flautists would have had to learn all new fingerings for Boehm’s flute. Though people appreciated Boehm’s flute, many of them were “discouraged by the new system of fingerings, flautists of old standing decided against it, because they could not resolve upon studying an entirely new instrument; and, possibly, they sometimes saw with displeasure that young artists, by adopting it, acquired an accession of means for producing greater effects in their performance”\textsuperscript{140}. Though there was a bit of backlash from older, less willing flautists in the community, the skills of the younger flautists using Boehm’s system drew attention to the advanced capabilities present on Boehm’s instrument. Buffet, a flute manufacturer, later improved Boehm’s key system by placing all of the flute’s rods, and axles on one side of the flute. He also changed the springs from flat leaf, to needle\textsuperscript{141}. This further improved Boehm’s already well-advanced flute.

In 1847, Boehm released another, final model of flute. For this model of flute, he focused on the acoustics of the instrument. Boehm’s 1847 flute featured “an internal bore of 19 mm in diameter... [with] the headjoint [decreasing] in diameter to 17 mm at the cork”\textsuperscript{142}. This allowed for notes that resonated better than the ones played on older flutes. Boehm also changed the shape of the embouchure hole. Improving on Quantz’s oval hole, Boehm made the hole  

\textsuperscript{131} Ibid.
\textsuperscript{132} Ibid.
\textsuperscript{133} Elva Lind Þorsteinsdottir, \textit{Theobald Boehm} (2010), 9.
\textsuperscript{134} Ibid.
\textsuperscript{135} Ibid.
\textsuperscript{136} Ibid.
\textsuperscript{137} Ibid.
\textsuperscript{138} Ibid., 10.
\textsuperscript{139} Ibid.
\textsuperscript{140} Ibid., 11.
\textsuperscript{141} Ibid.
\textsuperscript{142} Ibid., 13.
rectangular, rounding the corners. He also made the hole larger. This change in embouchure shape, and size allows for the best sound, and the most control over the instrument, which is still used by flutes today. Boehm also reworked his key system for a third time. He adjusted the size of the tone holes, making them larger. Again, these holes were too large to cover by fingers, but this time he replaced “all ring-keys and [Covered] all tone holes with padded hole covers”\textsuperscript{143}. Covering the tone holes with padded keys ensured that no air leakage would interfere with the pressing of the keys. Boehm experimented with making flutes out of different materials, searching for one that produced the best sound. Other flute manufacturers, Quantz for example, had in the past also tried out different materials for his flutes. By 1846, “numerous kinds of wood, ivory, crystal-glass, porcelain, papier-mache, and wax”, had all been experimented with\textsuperscript{144}. In 1847, Boehm produced the first all-metal flute (Figure 18). Flautists did not have to worry about the instrument splitting, the bore size changing, or the instrument being affected by temperature, like they would have with wooden flutes\textsuperscript{145}. In 1851, Boehm presented his flute at the Universal Exhibition in London. Sir Henry Bishop, an English composer of the time, stated that “Mr. Boehm has acquired not only perfection in the tone and tuning never before attained but also a facility in playing those keys which were hitherto difficult and defective in sonorousness and intonation”\textsuperscript{146}. His flute was no small invention, but rather it opened up possibilities that were previously impossible for the instrument. He presented his flute again, in 1855 at the Paris Exhibition, this time winning gold\textsuperscript{147}.

Following Boehm’s 1847 flute, new keys were added, with mechanical improvements on the body of the instrument. The first improvement was in the mechanics of the G# key. The first G# key, which was the one that was part of Boehm’s mechanics, was open. The second development on the G# key was by Vincent Dorus, a prominent Parisian flautist of the 19th century. In his mechanics, lowering the A key covered the G#, producing a G-natural. However, there were also issues with his mechanism. Since the spring strength of the G#, and the A key were different, it made the A hole key difficult to press\textsuperscript{148}. Not surprisingly, Boehm thought that Dorus’ G# key was inferior, and did not accept it as a valuable contribution to his design of the flute. Boehm, in response to Dorus’ G#, decided to create his own version of a closed G# key. Boehm’s system included two keys that “remained independent with a strong spring which required greater force”, to open\textsuperscript{149}. However, even Boehm’s system had its own problems. The intonation of the A was poor, and to correct it Boehm moved the position of the A tone hole. He adjusted the tone by moving the tone hole 1.2 millimetres above its previous position. Boehm, however, recommended the open G#, over the closed G#, and only made two flutes that included his closed G# mechanism. The Dorus G# key lasted only a brief time. Later, it was replaced by a duplicate hole on the inner side of the flute tube. This was because the A, and G# keys were operated by the second mechanism, and could not be separated. This lack of separate mechanisms caused a need for a duplicate key to produce a C#\textsuperscript{150}.

The next key added to the flute was the thumb Bb. This key was added by Giulio Briccialdi, an Italian flute virtuoso, and composer, in 1849, not long after Boehm’s 1847 flute was released. This key is important because it facilitates technique in flat keys. Bb is an awkward fingering when playing in flat keys. Essentially, he player has to think about playing a Bb, every time the note appears. With the Bb thumb key, the player can keep their thumb on the key so that

\textsuperscript{143} Ibid.
\textsuperscript{144} Ibid., 14.
\textsuperscript{145} Ibid.
\textsuperscript{146} Ibid.
\textsuperscript{147} Ibid.
\textsuperscript{148} Carolyn Nussbaum, \textit{The Mechanical Improvements of the Body of the Orchestral Instrument Since 1847} (Presented to the graduate Council of the University of North Texas, 1994), 5.
\textsuperscript{149} Ibid., 8.
\textsuperscript{150} Ibid.
whenever the fingering for a B-natural is played, a Bb is produced instead, eliminating a lot of hassle in tricky passages in flat keys. The only need to play the regular Bb fingering in a piece would be if a B-natural was to be played adjacent to a Bb. After seeing Briccialdi’s Bb thumb key, Boehm wished again, to make his own version (Figure 19). In Boehm’s Bb mechanism, the Bb key was placed below the B key, “in order to follow the succession of the chromatic scale on the flute”\(^{151}\). Because of Boehm’s so-called “intelligent”, and “practical”, placement of the Bb under the B key, he felt that his thumb Bb mechanism was superior to Briccialdi’s. Unfortunately, Boehm’s thumb Bb did not gain momentum in the community, and Briccialdi’s thumb Bb is the system that is still used on modern flutes.

After the Bb thumb key was added, the next key to appear on the flute is the C# trill key. The C# trill key is an optional key. The key was first used by Louis Lot in 1863, but was then patented by Mme, Cornelia Villedieu Laube, in 1909\(^{152}\). This key was created specifically to facilitate the C# trill, but also improves three other trills. The other trills that were improved are: B/C#, B#/C#, and F#/G#\(^{153}\). Unfortunately, though this key has many benefits, there are also some negative points. It is said that the “added weight of the C-sharp key and the extra tone hole are thought to have a negative effect on overall tone quality”\(^{154}\). Because of the pressure put on manufacturers to continually improve intonation, and tone quality, the C# trill key’s possible negative impact on the flute overall makes it a questionable addition to the flute, even though it does facilitate one of the most awkward trills on the flute.

Note facilitators are an important modern improvement to Boehm’s key system. The first note facilitator is the split-E mechanism. This mechanism allows for the A, and G# keys to work independently from each other\(^{155}\). This key corrected the intonation, and tone quality of E3. E3 was consistently sharp, with a weak texture, and a lack of clarity on flutes that used the closed G# key. Boehm actually started experimentation with a split-E, while he was experimenting with the closed G# key\(^{156}\). It was not until 1895, however, that the split-E was invented by, Djalma Julliot, a maker of flutes, and Paul Taffanel, a flautist, and conductor, and the founder of the French Flute School\(^{157}\). The split-E allows the “G-sharp hole [to be covered] so that the A and G-sharp keys move separately”\(^{158}\). This allows for the remaining use of Boehm’s fingering, without dulling the sound. The next note facilitator is the split-F# (Figure 20). The reason for the addition of this key is that F#3 is unstable, and quite sharp, which led manufacturers to try and relieve this problem. People first started trying to fix this issue in 1923, with Charles Gage’s “articulated B, F# device”, which never gained widespread acceptance. Next, Lambros Callimahos “designed a key that was operated by an additional trill key attached to a new key on the underside of the tube”\(^{159}\). This mechanism did not last very long either. It was not until Albert Cooper altered the Bb trill key into an F#3 key, that anyone else had any luck with making a mechanism that facilitated the high F#. “Because the F-sharp is high in pitch due to the extra venting over the B hole... the B perforated hole needs to be covered without covering the B hole itself”\(^{160}\). By turning the Bb trill key into an F#3 key, this allowed for the perforated B hole to be covered without covering the B hole itself. By adding this mechanism, the F# is stabilized in pitch, and intonation, making the note similar to

\(^{151}\) Ibid., 10.
\(^{152}\) Ibid., 11.
\(^{153}\) Ibid., 12.
\(^{154}\) Ibid.
\(^{155}\) Ibid., 13.
\(^{156}\) Ibid.
\(^{157}\) Ibid.
\(^{158}\) Ibid.
\(^{159}\) Ibid., 14.
\(^{160}\) Ibid., 15.
those surrounding it in the third octave of the flute. Unfortunately, however, the fingering for high F# had to change, as it was an unavoidable outcome.

The high C facilitator was invented in the 1930’s by George Barrere. Later, it was implemented by Verne Q. Powell, a flute manufacturer. This key allowed for the low B key on the foot joint to be closed, while the low C, and C# stay open. An issue with playing high C, C4, is that when the “low B footjoint is used, there tends to be a delay in response when playing C4”. This key, alternatively called the “Gizmo key”, was never patented, and was, and still is, available from most flute manufacturers, as it has become a staple key on modern flutes. Finally, the last major note facilitator that was added was the low C key. A lever was added to the foot joint which controlled the covering, and uncovering of the C4 tone hole. The lever for the low C key was invented by J. Thibouville-Lamy, and Cie. The lever was placed at the beginning of the foot joint, beside the right hand keys. The low C lever was operated by the player’s right-hand pinky finger, just as the low C, C#, and B keys are operated on the foot joint of modern flutes. Alternatively, the lever could also “be connected to the low B key in order to operate passages with b, and to act as an alternate high C facilitator”. This meant that flutes without a gizmo key could still control the facility of the high C, by having control over the opening, and closing of the keys on the foot joint through the use of the low C lever.

The modern era in flute design brought with it an emphasis on customizable aesthetics. Prior to the early 1900’s, closed hole key systems were the most frequently used. Starting in the 1920’s, however, flute manufacturers began preaching the benefits of open holed key systems. Manufacturers would advertise the advantage of being able to vent holes to adjust the tuning of flat notes, as well as the addition of the ability to play quarter tones. By venting the keys, meaning to press, or partially press the key, but leave the hole in the key uncovered, or partially uncovered, the sound, and tone would be changed, ultimately raising the pitch. Venting also allows for other techniques that would appear often in avant garde music. For example, an open-holed flute is “required when playing avant-garde music which includes other techniques such as multiphonics and glissandos”. Open holed flutes allow for a wide range of extended techniques, thus often making the open style of keys the style of choice for professional, and intermediate musicians, looking for an instrument that can handle multiple styles of playing equally well.

There are other customizable features one could get on a flute, as well. For example, flutes can be manufactured with a variety of metals starting with the cheapest flutes being made out of nickel for durability. Intermediate, and professional flutes are often made out of solid silver, with the option of also purchasing a flute of solid gold, or solid platinum, usually at special request. Each metal produces slight different characteristics in the sound, though this is debated. Besides choosing the body material of the flute, you can also choose the plating. Usually nickel flutes are plated in silver, rather than being made out of silver, to keep costs down, and improve the durability. Silver, however, can be plated in gold, or platinum. One could even get a head joint with a gold plated lip plate, leaving the rest of the flute solid silver, purely for aesthetic reasons. Engraving is also an option, if one wishes to buy a head joint with an engraved lip plate, or a flute with engraved keys. Though of course, for most flautists, no added engraving, or plating is needed, but rather this is for strictly aesthetic purposes.

161 Ibid., 16.
162 Ibid.
163 Ibid.
164 Ibid., 17.
165 Ibid., 19.
166 Muramatsu America, Platinum Clad, Muramatsu America (http://muramatsuamerica.com/instruments/platinum/).
The flute has travelled far in time, from its ancient history to the advanced orchestral instrument of today. Starting out as a simple bone with scrapped holes at 42,000 years old, to a solid metal instrument fitted with various axis, keys, and springs in the 21st century. The flute has had a long life full of improvements, of great importance throughout the history of music, and society. How will the flute be improved in the future? At this point in time, nobody knows, however, it is likely that as long as the instrument retains its vital role in music in society, the quest for improved tone, and intonation will remain a goal for flute manufacturers for many centuries to come.

Figures

Figure 1: The Geissenkloesterle flute, as displayed by the University of Tubingen (Steinzeit Musik, 11. Einfachrohrblätter: Steinzeitsaxophon (Steinzeit Musik, http://steinzeitmusik.com/11-einfachrohrblaetter-steinzeitsaxophon))


Figure 3: The six intact Jiahu flutes. (Brookhaven National Laboratory, Brookhaven Lab Expert Helps Date Flute Thought to be Oldest Playable Musical Instrument (Brookhaven National Laboratory News Release, September 22, 1999, https://www.bnl.gov/bnlweb/pubaf/pr/1999/bnlpro92299.html))
Figure 4: Three of the Jiahu flutes, including the 9,000 year old flute with altered seventh hole. 

Figure 5: The Yugue flute alongside a drawing for better clarity. (Sarah B. Barber, A divine wind: The arts of death and music in terminal formative Oaxaca, (ResearchGate, Figure 6. Yugue flute, lateral view, March, 2012, https://www.researchgate.net/figure/259423570_fig6_Figure-6-Yugue-flute-lateral-view))

Figure 6: Drawings of the carvings on the Yugue flute (Sarah B. Barber, A divine wind: The arts of death and music in terminal formative Oaxaca (ResearchGate, Figure 11. Graphic elements incised on Yugue flute (a) trefoil, (b) paired dots, (c) U-infixed motif, (d) pectoral, (e) mirror?, (f) crossed- bands, (g) handled implement, March, 2012, https://www.researchgate.net/figure/259423570_fig11_Figure-11-Graphic-elements-incised-on-Yugue-flute-a-trefoil-b-paired-dots-c))
Figure 7: A depiction of a woman playing the double flutes from a fresco in Beni Hassan (Thomas Lea Southgate, *On a Pair of Ancient Egyptian Double-Flutes* (Taylor & Francis, Ltd. On behalf of the Royal Musical Association, *Proceedings of the Musical Association*, 17th Sess. 1890-1891, pp. 13-33), 18.)

Figure 8: A coin from Caesarea, Syria, depicting a person playing a transverse flute. (Wild Winds, *Ancient Coinage of Syria, Caesarea Paniás*, (Wild Winds, Ancient Greek Coins, http://www.wildwinds.com/coins/ric/marcus_aurelius/_caesarea_panias_SNGANS_862.jpg))

Figure 9: A carving of a transverse flute found on an Etruscan urn. (Walter Maioli, *Flauti, dalla Preistoria all'Elettronica*, (Sound Centre, http://www.soundcenter.it/wmflauti.htm))

Figure 10: Medieval art portraying two women playing transverse flutes. (Greg Lindahl, *The Cantigas de Santa Maria: All Color Images*, (http://www.pbm.com/~lindahl/cantigas/images/all_color.html))
Figure 11: A one-keyed flute, popular in the 1600’s. (McGee Flutes, *The McGee-Flutes Research Collection*, (http://www.mcgee-flutes.com/collection.html))

Figure 12: An excerpt from Clerambault’s *Orphee* (Louis-Nicolas Clerambault, *Orphee*, (Petrucci Music Library, 1710) https://imslp.org/wiki/Orph%C3%A9e_(Cl%C3%A9rambault,_Louis-Nicolas))

Figure 13: Quantz’s two-keyed flute. (Martin Wenner Floten, *J. J. Quantz*, (Martin Wenner Floten, http://www.wennerfloeten.de/en/products/transverse-flutes/j-j-quantz/))

Figure 14: A selection from Quantz’s 6 Duets for 2 Flutes, QV 3:2 (Johann Quantz, 6 Duets for 2 Flutes, QV 3:2 (Petrucci Music Library, http://imslp.org/wiki/6_Duets_for_2_Flutes,_QV_3:2_(Quantz,_Johann_Joachim))
Figure 15: A flute manufactured in 1800 by Godfroy Aîne (UCT Library, *Concert flute in D with five keys*, (UTC Libraries Digital Collections, [http://www.digitalcollections.lib.uct.ac.za/collection/islandora-20480]))

Figure 16: (A comparison of Theobald Boehm’s 1830 model of flute, to a flute from the 1700’s. Elva Lind Þorsteinsdottir, *Theobald Boehm* (2010), 21.)

Figure 17: Boehm’s all-metal 1847 flute model (Library of Congress, DCM 0652: Theobald Boehm/Flute in C, (Library of Congress, [https://www.loc.gov/item/dcmflute.0652/]))

Figure 18: Boehm’s all-metal 1847 flute model. (Library of Congress, DCM 0652: Theobald Boehm/Flute in C, (Library of Congress, [https://www.loc.gov/item/dcmflute.0652/]))
Figure 19: Boehm, and Briccialdi’s Bb mechanisms in comparison. (Carolyn Nussbaum, The Flute: The Mechanical Improvements of the Body of the Orchestral Instrument Since 1847, (Presented to the Graduate Council of the University of North Texas, August, 1994), 11.)

Figure 20: A diagram outline the mechanics of the Split-F# mechanism. Carolyn Nussbaum, The Flute: The Mechanical Improvements of the Body of the Orchestral Instrument Since 1847, (Presented to the Graduate Council of the University of North Texas, August, 1994), 15.

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