# The History and Process of the Development of the Modern Flute

Sarah Vitullo

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Kevin Chiarizzio, D.M.A.
Thesis Chair

_____

Robert Mills, M.M.
Committee Member

_____

Michael Babcock, Ph.D.
Committee Member

_____

Marilyn Gadomski, Ph.D.
Assistant Honors Director

_____

Date

Abstract

The flute has gone through many phases of development starting from its early form to the modern model which is played today. Though many important flute makers, composers and musicians were part of this process, Johann Joachim Quantz and Theobald Boehm were the two major contributors to the flute's technological developments. The flute started as a simple tube with holes to which keys were progressively added by Quantz. Boehm completely redesigned the flute to enable the performer to cover more holes than the human hand fingers alone are capable. Although the work of Quantz and Boehm took time to become accepted, the developments have become an integral part of what is now known as the modern flute.

## The History and Process of the Development of the Modern Flute

The development of the modern flute is a complex process which has been ongoing for thousands of years. The major developments of the modern flute occurred during the 1700s and 1800s and were largely a product of Johann Joachim Quantz and Theobald Boehm. While other flute makers' contributions may be important, the improvements of Quantz and Boehm most influenced the instrument's design to better meet the demands of the musicians, the music, and the composers. The modern flute would not be the same without the inclusion of their innovations.

### Development of the Flute Prior to Quantz

The flute was played by primitive man for thousands of years, though in a much simpler form than is played today. Early flutes were constructed of a hollow tube with carved-out holes for the fingers to cover played in a vertical plane. The placement of the holes in the bore was determined based on a chosen tonal center.[1] The transition of the recorder, the primitive flute played vertically toward the ground, to the transverse flute is one of the early steps in the development of the flute. The first important change to the keyless cylindrical flute occurred around 1660. The new flute design included one closed key just below the E hole which produced D#, a note which could not previously be played on the keyless flute. The note was played by pressing the key with the right hand little finger to lift the hole-covering. Separate sections were also an important part of the new design. Tenon and socket joints attached the three sections of the instrument which

[1] Debost, Michel. *The Simple Flute.* (New York: Oxford University Press, 2002), 83.

now had smaller finger holes and was based on a D major scale. Many agree this new one-keyed form of the instrument was developed by the Hottettere family who were highly skilled in boring and fine-tuning small wooden tubes. Intonation problems were common because there were no holes for the main chromatic notes, including G#, Db, F, Bb; holes had to be partially covered by the fingers to produce these notes. Though intonation problems still existed, the single-keyed flute remained popular for about 100 years and was falsely considered to be a perfectly constructed instrument by the flute players of the time. By 1700, it is understood that the flute's bore had evolved into a tapered body that was divided into several pieces and the size of the embouchure and finger holes were made smaller.[2]

For many years, flute players struggled with intonation issues caused by poor instrument design of the hole sizes and positions. By the late 1700s, flute players acknowledged limitations of the current instrument design. Intonation was the main issue in need of improvement because of the unevenness of the scale and the limitation of performance in compositions in only a few tonal centers. Keys with more than three sharps or flats were considered impractical and unreasonable.[3]

The development of the flute took place in stages throughout several centuries. From 1675-1775, the flute was constructed of a conical tube with six finger holes and one key. This was an important development since previous flutes only had holes which the fingers covered, with no keys at all. From 1775-1850 the flutes used were conical with

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[2] Bate, Phillip. *The Flute: A Study of its History, Development, and Construction.* (New York: W. W. Norton & Company, 1969), 77-79. DeLorenzo, Leonardo. *My Complete Story of the Flute.* (New York: The Citadel Press, Inc., 1951), 7,8. Toff, Nancy. *The Flute Book: A Complete Guide for Students and Performers. 3rd ed.* (New York: Oxford University Press, 2012), 42.

[3] Bate, 90.

four to eight keys.[4] During the early 1800s, the flute was at its peak of popularity as a solo instrument and its possibilities in the orchestra were expanding as the instrument became better understood.[5]

For the flute to become a more prominent instrument, it was necessary for composers to write music which included it. Italian composers Striggion and Corteccia requested the flute to be part of their orchestra to accompany light plays and early operas as it was a popular instrument at this time in 1565. Sixteen years later the flute was included in the first performance of "Ballet Comique de la Reine" in France. Jacob Peri wrote a score which included three flutes for his opera, "Euridice". In 1600, the flute was included along with other stringed instruments in Emilio de Cavaliere's oratorio, "La Rappresentazione dell' Anima e Corpo".

Though the flute had the approval of some composers, others did not want to include the flute or did not think it was a worthwhile instrument. Monteverdi was known specifically for the exclusion of the flute in his opera orchestrations. He only used one flute in his opera "Orfeo" and the instrument was probably more similar to today's piccolo than a full-sized flute. [6] During the Baroque period, especially 1701-1750, the flute was labeled as *traversa* or *traversiere* meaning the transverse or horizontal flute. Sometimes the flute was also called a D flute since the natural scale made on the flute when each finger was lifted was a diatonic D scale.[7]

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[4] Carse, Adam. *Musical Wind Instruments.* (New York: Da Capo Press, 1965), 102.

[5] Bate, 103.

[6] Schwartz, H.W. *The Story of Musical Instruments: From Shepherd's Pipe to Symphony.* New York: Double Day, Doran & Company, Inc., 1939), 63-65.

[7] Sachs, Curt. *The History of Musical Instruments.* New York: (W. W. Norton & Company Inc., 1940), 381.

## Influences on Johann Joachim Quantz

Johann Joachim Quantz (1697-1773) was the greatest flute virtuoso of his time. He was the flute teacher and court musician of Frederick the Great of Prussia.[8] Quantz, son of Andreas Quantz, a blacksmith, was born in Oberscheden in Hanover on January 30, 1697. As a nine-year-old, Quantz expected to follow in his father's footsteps as a blacksmith, but his father died in the spring of 1707. Quantz's uncle, Justus Quantz, a court musician, adopted him and began to teach him music. Three months later, Quantz's uncle also died and young Johann went to stay with Johann Adolf Fleischhack for about seven years. Quantz's motivation and desire for knowledge allowed him to grow and gain knowledge during this time. Quantz was a talented instrumentalist very well-rounded instrumentally as he studied the violin, hautboy, trumpet, while also being acquainted with various wind and string instruments.[9]

Quantz was known for many aspects of his musical career, including being a composer, teacher, and flute manufacturer. He did not consider himself to be a flute maker though. He was a musician who understood the difficult phases of the work but left the mechanics to the skilled craftsman under his supervision. Quantz was concerned with several main factors: pitch relationships, instrument characteristics, style of a composition, and the way it is played. His flute making was influenced by his goals as an accomplished performer and his knowledge as a composer.[10]

The most formative period in Quantz's life was the 25 years he spent as a musician in Dresden, where he performed quality music and met musicians, including

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[8] Schwartz, 70.
[9] Schwartz, 70. De Lorenzo, 69-70.
[10] Reilly, 429, 431.

violinist Goerg Pisendel (1687-1755), a great mentor who inspired and guided him through his life and career.[11] Quantz's expression in slow movements improved with the help of Pisendel. By listening to vocalists and instrumentalists Quantz increased his stylistic knowledge. He also studied harmony and counterpoint with Pisendel.[12] Pisendel had studied with a great Italian singing teacher, so Pisendel's mentoring influenced Quantz's perception of what the flute should sound like. This is how Quantz developed the idea that the natural flute range should not reach higher than the human voice.[13]

At age 17, Quantz settled in Dresden, but was unable to find a job so he was employed as a musician in Radeburg. Quantz travelled to Pirna in search of work and ironically, ended up working in Dresden as because his employer frequently sent Quantz to Dresden for various assignments. Working in Dresden in 1716 was a rich musical experience as Dresden was a mecca for the top musicians of the day and the Royal Orchestra was at the height of excellence. Quantz had the experience of listening to performances by famous artists and he realized his deep passion for music, which he desired to cultivate further.[14]

During 1717 and 1718 Quantz travelled around Germany and Austria, finally returning to Dresden.[15] At this time he began studying the flute with Pierre Gabriel Buffardin (1690-1768), the principal flute player of the Royal Orchestra in Dresden.

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[11] Mary Oleskiewicz. "The Flutes of Quantz: Their Construction and Performing Practice." http://www.jstor.org/stable/842324, 203.
[12] De Lorenzo, 70-71.
[13] Reilly, 433-434.
[14] De Lorenzo, 70.
[15] Ibid., 70-71.

Quantz studied with Buffardin for four months, at which time Buffardin died.[16] Quantz's technical proficiency increased and allowed him to perform for technically demanding music as a result of his lessons from Buffardin.[17]

Once Quantz entered adulthood, he spent 25 years (1716-1741) in Dresden as part of the royal orchestra.[18] Quantz served as an oboist and then a flutist in Dresden and Warsaw at the court of the Elector of Saxony and King of Poland, Augustus II, and Augustus III.[19] Quantz enjoyed the prosperous musical environment which he experienced while in Dresden, but desired to enhance his musical education through traveling around Europe,[20] so he spent three years (1724-1727) touring Europe to familiarize himself with the musical culture of Italy, France, and England.[21]

## Quantz's Contributions to the Development of the Flute

During his travels in Italy, Quantz met Antonio Scarlatti, who was not very interested in wind players because he felt they all played out of tune. This gave Quantz a new perspective on the intonation of the flute as well as a desire to redesign the instrument.[22] Quantz was the first flutist to use his advanced playing abilities and artistry on the flute to prove to Scarlatti that the flute was indeed a valuable musical instrument.[23]

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[16] Powell, Ardal with David Lasocki. "Bach and the flute: the players, the instruments, the music." *Early Music.* 23, 1(Feb 1995), 19. De Lorenzo ,69-71.

[17] De Lorenzo, 70-71.

[18] Howard Mayer Brown. "On Playing the Flute by Johann Joachim Quantz: Edward R. Reilly." http://www.jstor.org/stable/830797, 301.

[19] Walthall. "Portraits of Johann Joachim Quantz." http://www.jstor.org/stable/3127517, 501.

[20] Rachel Brown, "Private Passion." http://go.galegroup.com/ps/i.do?action=interpret&id=GALE, 15.

[21] Howard Mayer Brown, 301.

[22] Rachel Brown, 15.

[23] Schwartz, 70-71.

Once Quantz realized that intonation on the flute was problematic, he began the talk of improving this aspect of the flute to make it more pleasing to the listening ear. As a result of meeting with Scarlatti, Quantz designed separate Eb and D# keys for the flute, improving the intonation of those pitches.[24]

**Solving the Problem of Intonation**

Prior to the time of Quantz's developments, poor intonation was blamed on the performer as opposed to the instrument. Quantz was intent about the specific way to maneuver the flute for proper intonation. He would turn the flute in or out or partially close or open holes.[25] Quantz worked at the Prussian Court to overcome some of the problems of the flute, specifically mechanical and technical issues, such as hole placement and development of keys. This specifically made accurate intonation a major problem for two reasons. Tuning the instrument was difficult because as the instrument warmed up with playing, the pitch center would rise.[26] There was no standard of pitch during the 1700s which added complications as well.[27]

[24] Rachel Brown, 15.
[25] DeLorenzo, 7, 8.
[26] Bate, 91.
[27] Rachel Brown, 17, Bate, 91.

**Use of the *Corps de rechange***

Quantz' created the *corps de rechange*, a collection of different length sections to insert into the flute. Construction of the flute in four sections was in response to the problem of pitch variation during this time. The added fourth section was the part that could be selected by whichever length was needed. There was a selection of various lengths of upper joints for the flute from which the appropriate length joint would be chosen and inserted into the flute changing the size of the tube, according to the desired pitch. This created an acoustic problem for proper intonation because the fingers needed to be repositioned for each joint. This problem was eventually solved by the inclusion of a tuning slide made of telescopic metal tubes which would be pulled farther apart or pushed closer together according to the desired intonation. The idea of the *corps de rechange* was still beneficial while in use. Flutists would use a longer joint for lowering the pitch during an allegro movement where the increased blowing force required to project the sound above the orchestra would result in a sharper pitch. In contrast, during the adagios of 18th century Mozart compositions, shorter tubes were beneficial to raise the pitch.[28]

**Addition of a Second Key**

Quantz's work with the intonation of the flute depended on the system of intonation he followed. The system of tuning used by Quantz was called the mean-tone system which clearly distinguished enharmonic pitches so the pitch D# sounded different

[28] Bate 91-93.

from Eb. For this reason, Quantz desired to improve the discrimination between enharmonic pitches.[29] Quantz promoted the addition of a second closed key to the footjoint, providing a distinction between D# and Eb. He is known to have had the key added, meaning that someone else did the work to create this key, but it was Quantz's idea.[30] Quantz felt strongly that enharmonic differences on the flute should be recognized and he thought this would be the last correction needed. The flute was so out of tune as a whole, that it is difficult to understand Quantz's determination to fix a specific flaw instead of addressing intonation as a broader issue. The Eb key was placed next to the D# key but a little bit lower, and it had a slightly larger hole.[31] Quantz was proud of his flute design with the D# and Eb keys and he used this flute during the remainder his life. To his disappointment, his invention of the flute with two added keys did not become popular outside of Germany. [32]

The F natural, G# and Bb holes were made and covered with keys. Around 1770 and 1780 these flutes were introduced in London and a few professional flute players of the day were intrigued enough to play these new flutes with six keys. Soon others began to follow their model, first in England and throughout Europe.[33] Flute players had trouble accepting the addition of keys for several reasons. Some flutists felt the idea of the need for keys was implying a poor perception of their technical ability. Others were unsure that the key mechanism would be adequately designed to provide stable and

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[29] Reilly, Edward R. "Quantz and the transverse flute: some aspects of his practice and thought regarding the instrument" Early *Music.* 25,3(Aug 1997), 429.

[30] De Lorenzo, 7-8, Reilly, 429.

[31] Schwartz, 70, 72.

[32] Bate, 93-94.

[33] De Lorenzo, 7-8.

reliable spring action and consistent sealing of the holes. Finally, fingering alteration to produce the pitches created another roadblock for acceptance.[34]

**Materials Quantz Used in Flute Development.**

Quantz constructed many different flutes in his lifetime. Quantz benefitted greatly for the patronage of Frederick who was able to provide ample resources to support his experiments including ivory and whole tree trunks of boxwood, ebony, kingwood, lignum vitae, and grenadilla, to aide Quantz in his flute construction. Quantz had strong opinions about how the flute should be made and the sound it should produce and this wide variety of resources provided him with many choices to work with. Quantz believed that ebony flutes created the clearest and most beautiful tone, though boxwood was the most popular wood. He constructed his flutes out of dense wood with a wide bore and thick walls in order to create a deep, robust sound in the low register.[35]

While under the patronage of Frederick the Great, Quantz made flutes of several types of materials for Frederick, including glass and amber. There has always been a debate on the best materials for flute construction. Generally, metal flutes are easier to play than wood flutes because of the less breath required for playing, easier care and upkeep of the instrument, and the ability to produce pitches in the higher octaves with relative ease. Experimentation with other materials such as glass and amber had been used.[36]

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[34] Toff, 45.
[35] Rachel Brown, 16-17.
[36] DeLorenzo, 56-57.

## Composers' Influences on Flute Development

The history of the development of the flute is closely related to the development of the flute music. The physical characteristics of the instrument no doubt determined the technical content and stylistic features found in flute music. It is not by accident that since 1700 the structural and mechanical development of the flute directly relates to the development of compositions for the flute.[37] During the Baroque and Classical periods many composers promoted increased prominence of the flute by writing music for it. Among these composers were Quantz, Georg Philipp Telemann, Carl Philipp Emanuel Bach, Joseph Haydn, and Wolfgang Amadeus Mozart. Many flutes from the baroque and classical periods have been discovered which indicated the flute's increasing popularity during this time. The music written for flute was for both solo and ensemble settings which was great motivation for flute makers to improve the acknowledged faults of the instrument. The increased employment of the instrument in music of the time led to the continued modification of the modern flute.[38]

Bach, Haydn, Mozart, and Beethoven had varying approaches to writing for the flute.[39] There are varying opinions on Bach's writing for the flute as some question why he wrote flute music the way he did and they question whether he actually wrote the music for the flute.[40] Bach and Handel wrote many flute sonatas which have become part of the standard repertoire.[41] Haydn's scoring of the flute foreshadowed of the flute's upcoming role in the symphony orchestra, though he used it in limited terms in the

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[37] Toff, 41.

[38] Zapata, Ricardo. "The making of the almost perfect flute." *Magazine Antiques* 172,6 (Dec 2007): 102.

[39] Bate, 174-175.

[40] Powell, Ardus with David Lasocki, 9.

[41] DeLorenzo, 351-353.

middle register from F4 to F5. Mozart he wrote at least nine solos for flute which were limited to the keys of C, D, A, G. He was clearly cautious towards the issue of intonation and wrote only in simple keys because of the limits of the flute during that time. When Mozart wrote for opera, his confidence in the flute was limited to maintaining a tessitura in the upper and middle register. [42] Mozart's well-known comment that the only thing worse than a flute was two flutes, which may explain some of his hesitations in incorporating more writing for the flute in his compositions.[43]

## Influences in the Life of Theobald Boehm

The next main contributor to the development of the modern flute after Quantz was Theobald Boehm, son of Karl Frederick Boehm, a talented jeweler and goldsmith. Born on April 9, 1794 in Munich, Bavaria, Theobald Boehm was credited with having designed and built the first modern flute in the early 1800s which had a new key system. He used his skills as an accomplished craftsman to create a comprehensive approach to reinventing the mechanical system of the flute.[44] Boehm was a scientist, a musician, an inventor, experimenter, metal worker, craftsman and flute virtuoso. Boehm's background and experiences uniquely qualified him for combining musical instrument construction with the scientific and acoustical requirements needed for the flute's transformation. [45]

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[42] Bate, 174-175.

[43] Wynn, James. "The Flute." The Musical Quarterly. 15, 5(1929): 469-474. http://www.jstor.org/stable/738333 , 471, 472.

[44] Debost, 84, Bate 115, DeLorenzo 121.

[45] Phelan, James. *The Complete Guide to the Flute from Acoustics and Construction to Repair and Maintenance.* (Conservatory Publication: Boston, 1980), 1-2.

## Boehm's Contributions to the Development of the Flute

Boehm was the principal flutist of the Munich theatre. He was inspired by hearing the great English flute player Nicholson perform in London and realized that the holes on the flute should be redesigned and positioned with the goal of creating an accurate scale in three octaves, rather than the holes being spaced where the fingers felt comfortable. After placing the holes in the correct places, he then devised the key mechanism that would reach the holes where the fingers could not in order to properly close and open these holes.[46]

From Boehm's childhood he enjoyed music and was given his first flute at age 15. He was instantly enthralled with this one-key boxwood flute. He eventually became unhappy with this instrument after realizing its faults. This led to the creation of the four keyed flute which Boehm designed after the model of the Dresden flute maker, Karl August Gresner. This flute was constructed with six holes and four closed keys to cover D#, G#, Gb, and F natural. [47] Before he turned 21, Boehm was already a master of the 8-key flute and played in the Royal Bavarian Court Orchestra. He later became a soloist in Paris and London. Through his performing, he became interested in the construction, key mechanism, and tuning, which eventually led to his later developments.[48] The Boehm system flute was originally of conical shape when designed in 1832, but was redesigned in 1847 to a cylindrical shape.[49]

Boehm's flute provided the transition point of development from the primitive flute model to the first modern instrument. His work on the flute is considered to be a

[46] Bate 117, Carse, 94, Schwartz, 75.
[47] Zapata, 104, Schwartz, 74
[48] Schwartz, 74.
[49] Carse, 102.

classic example of scientific principles for systematic instrument design. His work made the instrument easier to construct, learn, and play contributing to the increased popularity of the instrument. His design was technically profitable, but also created new responsibility for flute players. The intricacy of the mechanism of keys, levers, rods, and pads which were required for accurate intonation and beautiful tone quality necessitated more care to protect the fragility of the instrument.[50]

**Materials Boehm Used In Flute Development**

Boehm experimented with the materials used for flute construction as well. Boehm indicated that flutes were constructed out of many materials including wood, ivory, crystal-glass, porcelain, rubber, papier-mâché and wax. Boehm believed that the lighter the flute, the more easily tone could be produced with full strength and less blowing. Production of a bright tone with less fatigue became easier on a flute constructed of metal than one of wood. Differences in the hardness of the material affected the timbre of the instrument.[51]

[50] Phelan, 1-2.

[51] Boehm, Theobald. *The Flute and Flute Playing: In Acoustical, Technical, and Artistic Aspects.* translated by Dayton C. Miller. (New York: Dover Publications, Inc., 1964), 53-54.

**Boehm's work as a flute maker**

In 1828, Boehm took the initiative to start his own flute factory where he could build the instruments to his own preferences. He was displeased with the manner of construction for flutes with crudely made keys unsystematically hinged onto the flute with wire and a lump of wood. He used his goldsmith skills to develop a new idea for the key mechanism which had metal posts screwed into the wood of the flute. The keys were hinged on small axles positioned between the metal posts so that they could pivot to open and close the keys.[52] Boehm's initial enhancement of the flute took place in 1832 but it took time for this new flute to evolve and eventually gain acceptance.[53]

The fact that this new flute was made of silver, which created a much brighter timbre, and could play in tune created quite a controversy. The new key structure mechanism required flute players to learn new fingerings.[54] Boehm's new system was centered on a chromatic scale, not a diatonic scale as before. In order for Boehm's flute enhancements to gain acceptance, musicians and instrument makers would need to accept his designs and consequently popularize them in the separate musical communities. The first to purchase Boehm's patents and commercialize his metal flutes were the French flute makers, Godefroy, Louis Lot, and Bonneville.[55]

Boehm's development of this new design was called the ring-key system which involved keys being connected so that one finger could press down two keys. All of the keys were open, for the exception of the trill keys and the D# key. His ring-key system

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[52] Schwartz, 74.
[53] Kocher, Stephanie, "Boehm's Very Good Idea," *Flute Talk,* January 2006, 14.
[54] Debost, 84, Sachs, 409-410.
[55] Debost, 84.

had a conical bore made of grenadilla or cocus wood with tone holes resized to the correct proportions, so they were no longer all the same size. Although Reverend Frederick Noland developed and patented the open key rings, Boehm's design was the initial time most every of keys were open, with the exception of the D# and trill keys. With Boehm's system the tuning slide was removed and rod axles were constructed on each side of the flute.

Boehm's flute had its first introduction in a performance for the public in Munich on November 1, 1832 with a subsequent performance in Munich on April 25, 1833, followed with performances in London and Paris. These performances included explanations of the new design since playing the instrument involved major tone and fingering alterations. Boehm submitted it to the Paris Academy of Sciences but he received no feedback. Between 1833 and 1835 in London only one flute of the new design was sold. Boehm had difficulty receiving a patent for his new ring key system but soon other instrument makers such as Auguste Buffet, Victor Coche, and Louis Dorus began to experiment with his ideas. This modified Boehm system flute was examined at the French Academy of Fine Arts and the Paris Conservatoire continued to reject it. In London, Paris, and New York flute makers began constructing flutes using this model.[56]

In 1839 Boehm sold his business to his partner and later started manufacturing flutes with other business partners in London and Paris. He then began his acoustical studies which led to further developments. The experiments he conducted led to a

[56] Kocher, 14.

diagram called the Schema.[57] The Schema was Boehm's diagram showing the placement and construction of tone hole centers. [58]

*Figure 1 Boehm's Diagram.*[59]

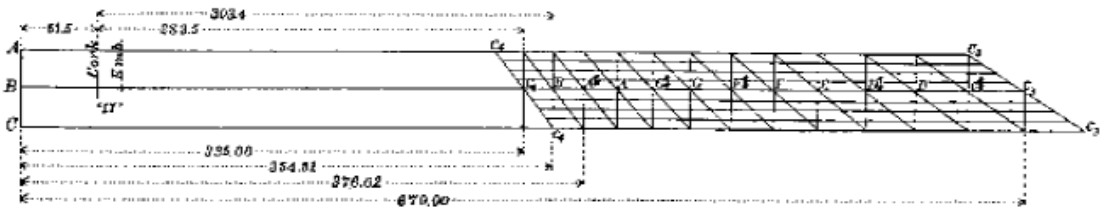


FIG. 12.
*Schema* for determining the positions of the tone-holes of wind Instruments at various pitches.

**Boehm's acoustical studies.**

Boehm was having difficulty with his instrument designs being accepted and decided to search for answers. Boehm attended the University of Munich where he studied acoustics under Professor Carl Emil von Schafhautl. Boehm spent 1846 and 1847 exploring the physical principles which influenced the design and operation of the flute. His research involved many experiments aimed at improving his designs and comparing possible materials for construction of the instrument. During his time of experimentation the standard frequencies for A was A = 435 Hz.[60]

Three main aspects which he worked on developing were the flute's intonation, response, and tone quality. The intonation was crucial because only skilled musicians were able to play the instrument in tune. Musicians with well-developed embouchures

[57] Kocher, 14, Bate, 121.
[58] Boehm, 37-38.
[59] Boehm, 41, picture of Boehm's schema diagram.
[60] Phelan 1, 10, Zapata, 105.

were able to produce a good tone quality, and usually these musicians were male because of the incredible power needed to produce a good sound. Flute players had to be skilled in forming the correct shape of the lips and tongue; otherwise the tone would be dull, lifeless and fuzzy sounding.[61]

Boehm's study of the acoustic proportions of the flute was instrumental in his perfecting the intonation of the flute. Boehm constructed his flute from three main sections, the head-joint, middle-joint, and the foot-joint as opposed to the four used by Quantz. A cork plug was used to close the tube off above the mouthpiece. The main body of the flute was a cylindrical tube with a diameter of 19 millimeters which decreased by two millimeters towards the cork at the top of the flute. Boehm constructed both conical and cylindrical tubes of varying sizes and types of metal and wood to find out how the intonation, tone quality, and response differed accordingly on each instrument. Accurate tuning on the flute depends on the size and distance of the hole from the upper end of the air column, so the exact location of the hole is crucial.

Through Boehm's experiments with the tubes of various shapes and materials, he reached four main conclusions which helped him arrive at the most efficient way to construct the flute. First, a strong and clear tone is in proportion to the volume of air in vibration. Second, a contraction in the upper part of the flute bore influences the tones and tuning of octaves, so intonation changes when the head joint is pushed in or pulled out. Third, the contraction made in the bore of the upper part of the flute must be geometrically proportioned, close to the curve of a parabola. Boehm's final conclusion was focused on the top quarter of the headjoint. The formation of the sound waves

[61] Schwartz, 75.

worked best with a cylindrical tube that was narrower at top of the headjoint so the diameter was reduced by one tenth at the cork. Therefore though the flute is a cylindrical tube, the head joint is contracted toward the cork at the end so the diameter at the end of the flute near the cork is narrower than the diameter of the rest of the tube.

Boehm diligently worked to determine the proper location of tone holes. He discovered that if the holes were too small the vibrations would be disturbed. This made tone production more difficult and could cause unwanted harmonics to sound. Smaller holes would also distort tone waves, producing poor tone quality. If the holes were incorrectly placed, the pure intonation in the third octave would be affected. For these reasons, Boehm designed his flutes with large tone holes which he placed in exact locations in order to produce powerful tone qualities.[62]

Boehm discovered through his experiments that a flute with a tube diameter of 20 millimeters would be more conducive to the production of a pure and full tone throughout two octaves. The problem, however, was that flute music demanded an expansion of the range of the flute to three octaves. This led Boehm to decreasing the tube diameter to 19 millimeters in order to compromise for the expansion of the third octave, though slightly taking away from the two lower octaves. Another problem encountered was figuring out a way to make the cork at the top of the head-joint moveable so adjustments closer to or farther away from the center of the embouchure would be possible. Boehm concluded that the cork should be 17 millimeters from the center of the embouchure in order to create the right balance for intonation. After determining the placement of the cork,

[62] Boehm, 26.

Boehm determined the size and form of the embouchure hole which is essential to tone production.[63]

## Composers' Use of the Flute After Boehm's Developments

Many composers throughout history utilized flutes in major works for unique purposes relating to tone qualities or special sounds. The flute would not have been useful in these ways without Boehm's development of the flute including its technical abilities and tone qualities. Beethoven wrote important flute parts in his orchestra works including a famous bird-like passage in the Andante of the *Pastoral Symphony*. Weber used the flute in his "Der Freischutz" to provide a haunting effect, Tchaikovsky's "Danse des Mirlitons" from *The Nutcracker*, incorporated bright and happy sounds, and Rachmaninoff's *Piano Concerto in C Minor* includes a melancholic flute part.[64]

## Additional Flute Modifications After Boehm

Boehm skillfully and systematically took the flute from its unrefined, out-of-tune, elementary state and created the scientifically-proportioned, well-crafted, and in tune modern flute. His design has remained consistent for many years, though a few aspects of his model have been slightly altered; some successful, some unsuccessful. Vincent Joseph Dorus (1812-1896) was a French flute virtuoso who studied at the Paris Conservatory and made an important change to the Boehm flute. Dorus changed the G#

[63] Ibid., 14-21.
[64] Wynn, 471, 472.

key from open to closed, which was debated because the third octave E is weakened with the G# key closed. Those who preferred the open G# felt that the scale was more logical with only one hole being opened at a time. To Boehm's dismay, this alteration of his design became widely accepted.

Guilio Briccialdi was an Italian flutist and composer. He was so excited about the newly designed Boehm flute that he mastered it and performed with it two short weeks later. He designed a lever or key called the Briccialdi Bb key which was added to the left hand thumb.[65] In the original Boehm system there was only one thumb key used for B natural and the first finger on the right hand was added for a Bb. The Briccaldi Bb key has become an important alternate fingering option when playing in a flat key or a fast passage. If both a Bb and B natural must be played in succession, the thumb has to switch between two thumb keys or the B flat is played with the right first finger as Boehm's original model was designed. A side key was also developed which can be played with the right hand first finger as another Bb alternate key, though it was originally used at a trill key for B and C instead of trilling with the left thumb. This key was more efficient because it had better ventilation and made certain passages easier, such as those with combinations of G and A# or Bb and B natural. The split E mechanism for an improved high E and a low B foot joint extension are additional features that are still in use. [66]

There have been changes to the footjoint of the flute including the addition of the C# gizmo key and the option of the B footjoint instead of the C footjoint. The C# gizmo

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[65] DeLorenzo, 9-10, 135, 321.

[66] Baines, Anthony. *Woodwind Instruments and Their History*. (New York: Dover Publications, Inc., 1991), 63.

key option is useful because it facilitates the high C and C#. One main benefit for having a B foot is to be able to play compositions that include a low B, but otherwise its use is limited. With the original Boehm system, the footjoint reached middle C, though now many footjoints reach a half step lower to B. The longer B foot is heavier, which can make the right hand position more difficult, takes longer to warm up than the C footjoint, and can make the low register and high notes harder to produce in contrast to the easier response on the C footjoint. The B foot also gives a beautiful full, dark sound, better intonation in the high register, cleaner response on the high F#, and a rich tone on the overall span of octaves which the flute plays.[67]

Boehm's flute design is still the model used today but there have been several totally new designs, some additions and modifications added to the Boehm design to aide specific notes, and continued developments on the traditional conical flute catered toward players who prefer the old flute fingering structure. One new design was by Cornelius which was accepted by amateur flutists, but was not accepted by any professional flutists so the instrument did not become popular.[68]

A few other types of flutes have been designed but none have lasted and the Boehm model still prevails. Robert Dick created a new design for the flute with new possibilities for combinations of closed and opened holes. Albert Cooper, the English flute maker produced a flute according to this design which worked to create a successful sound, but did not function well mechanically. In the 1990s two flute makers produced a newly designed flute that would made quarter-tone production possible. American flute

[67] Toff, 23-24.
[68] Bate, 134-136.

maker Bickford Brannen worked together with the Dutch flute maker Eva Kingma to produce the Kingma System flute in 1994. This new flute had small keys on top of larger keys so there was an option of smaller or larger holes. This new design preserved the traditional Boehm system while allowing for a much larger sound capacity.[69]

## Reflections and Conclusions on the Development of the Flute

The development of the flute was positively and significantly impacted by Johann Joachim Quantz and Theobald Boehm. Both men worked to develop the flute to advance beyond its limitations to meet the demands of the musicians, the music, and the composers. The most significant changes and developments of the flute occurred during the 1700s and 1800s. The flute had its major developments through Quantz and Boehm, but continued experiments are made. Thankfully, flutists that came before us did much of the hard work. The instrument on which flutists now perform would not be able to serve its musical purpose today without the efforts of Quantz and Boehm.

[69] Dick, Robert. "Acoustics: Real Life, Real Time- Why the Flutist and the Flute Had to Evolve." *Leonardo Music Journal.* 22.1(2012): 15-16. Project Muse. Web. http://mus.jhu.edu/, 16.

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