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The History of the Clarinet

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The Evolution of the Clarinet: A Three Hundred Year History

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The Evolution of the Clarinet: A Three Hundred Year History

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Pitch Designation Diagram

Finger Designation Diagram
The term clari\textit{net} can be applied to any single-reed wind instrument with a cylindrical bore.\textsuperscript{1} With this most inclusive of definitions, the history of the clari\textit{net} can be said to extend back to at least 2700 B. C. E., when the memet is known to have been used in Egypt. The memet differed greatly from the modern Western clari\textit{net}, however, constructed as it was of two joined tubes with individual mouthpieces to be inserted into the mouth of the player simultaneously (Kroll 12). Other examples of early multiple-tube clari\textit{nets} include the Egyptian arghul (of ancient origin but still in use), the aulos of ancient Greece, and the triple tube launeddas from Sardinia (c. 900-500 B. C. E. and still in use) (Rice 2). In northern Europe, from the Middle Ages until the beginning of the eighteenth-century, single-tube instruments were preferred. Examples include the brelka from Russia, the Hungarian tarogato, and the pibgorn (or Welsh hornpipe) from North Wales. These instruments, despite their single-tube construction, can again only be considered clari\textit{nets} in the most rudimentary sense.

The evolution of many different types of modern clari\textit{nets} is well documented. Various cultures from around the world have taken the basic principles of the clari\textit{net} in unique directions. One example of this is the transverse clari\textit{net} from Africa, a
horizontally held single-tube instrument with gourd resonators (NGDMI 403). The purpose of this study, however, is to restrict our definition of the clarinet to allow a detailed discussion of the evolution of only that modern clarinet which finds its origin in the late seventeenth-century in the form of an instrument known as the chalumeau. From this point onward then, any use of the term modern clarinet will be in reference to instruments which stem from this specific lineage.

There is no precise date available to indicate when the chalumeau (plural: chalumeaux) first came into existence. The New Grove's Dictionary of Musical Instruments (NGDMI) asserts that it is likely that the chalumeau evolved in the late seventeenth-century from attempts to increase the volume of the recorder as there are significant physical similarities between the two instruments (328). Other sources, however point to the possibility of a much earlier date, perhaps as early as the middle of the sixteenth-century (Rice 7). In either case, the chalumeau's physical characteristics at the end of the seventeenth-century were significant in the evolution of the modern clarinet.

The chalumeau of the late seventeenth-century, like many other early clarinets, was a single-tube, single-reed, cylindrical bore instrument. Beyond these basic characteristics, however, the instrument was unique in several respects. First, unlike other early clarinets, the chalumeau, at least in some cases, employed a detachable resonator or reed (a characteristic which allows it to be categorized as a
heteroglot instrument). All other early clarinets were idioglot instruments; that is, their reeds were inseparable from their bodies. In addition, the mouthpiece of the chalumeau was angled to allow for its insertion into the mouth thereby allowing direct control over the vibration of the reed.\(^2\) Many other early clarinets (e.g. the pibgorn) did not allow for direct contact with their reeds as they were enclosed in tone chambers.

Although chalumeaux of varying sizes are known to have existed at the end of the seventeenth-century, the most common chalumeau was the model pitched in C, an instrument which was no more than 12 inches long.\(^3\) The range of the instrument was somewhat limited, but its exact extent is a matter of controversy. Some sources claim the chalumeau could not overblow at all, giving it a range spanning just over an octave (Kroll 14). Rice and others, however, claim that although the chalumeau could overblow, its construction did not willingly lend the instrument to this practice (Rice 19, NGDMI 328). In either case, the chalumeau seems to have sounded best and was mostly played in its fundamental register. A further description of the chalumeau at this time reveals that it was a keyless instrument pierced with seven tone-holes. In addition, unlike the modern clarinet, it had no barrel or bell.

Although the chalumeau described above is much closer akin to the modern clarinet than other early clarinets, it would be incorrect to assert that the modern clarinet was a natural outgrowth of the chalumeau. For this to occur, a mechanical alteration would need to be provided to give the instrument
access to its upper harmonic series, allowing the chalumeau to
more than double its range. Although there is no conclusive
evidence, the most commonly held belief today is that the person
responsible for the invention of the clarinet was Johann
Christoph Denner (1655-1707), a highly regarded late
seventeenth-century instrument maker from Nuremberg. The
strongest and most widely quoted source for this claim comes
from J. G. Doppelmayr's Historische Nachricht von den
Nurnbergischen Mathematicis und Kunstlern of 1730, in which he
states:

At the beginning of the current century [the 18th
century], he [J. C. Denner] invented a new kind of
pipe-work, the so-called clarinet, to the great
delight of all music-lovers, discovered again from
ancient times the already well-known stick or rackett
bassoon, and at length presented an improved
chalumeau.

(Rice 17-18)

Unfortunately Doppelmayr's wording is ambiguous. Whether
Doppelmayr means to assert that the invention of the clarinet is
equivalent to the improvement of the chalumeau or that the
invention of the clarinet and the improvement of the chalumeau
are separate achievements is unclear. Given Doppelmayr's
inclusion of J. C. Denner's contributions to the revival of the
bassoon, however, a certain logic would lead one to believe that
Doppelmayr means to assert that Denner both invented the
clarinet and improved the chalumeau. Further support for this
claim lies in the fact that the chalumeau, despite the invention
of the clarinet in the late seventeenth or very early eighteenth-century, continued to flourish until the very end of the eighteenth century, mostly due to the inability of early clarinets to play in the chalumeau (or fundamental) register effectively (Grove 328). In addition, Kroll suggests that the chalumeau was specifically improved by J. C. Denner through the addition of two keys, placed separately on the front and back of the instrument (above the thumb-hole) to enable the instrument to increase its range (Kroll 14). Stubbins concurs with this suggestion and goes even further by stating that J. C. Denner, in his attempt to extend the range of the chalumeau, unexpectedly 'invented' the clarinet:

What J. C. Denner really did, must have been to obtain a kind of accidental result from the addition of two keys, to extend the limited range of this old instrument [the chalumeau]...The slight opening of one or another of these keys, which were both equidistant from the end, must have provided the sudden experience of facilitating the production of the third partial vibrational mode, and the clarinet was born.

(142-143)

Whether or not the invention of the clarinet was accidental, it is clear from extant specimens, including one of J. C. Denner's own clarinets, that the earliest clarinets were far from perfection. A brief explanation of the acoustical properties of the clarinet will be helpful in explaining why. Because, as Stubbins suggests, the invention of the clarinet was more or less an accident, the location of the keys on Denner's improved chalumeau were not ideally designed for the accidental
ability of the instrument to access the upper registers. Acoustically, in order for the clarinet to access the upper registers effectively, it must be fitted with a narrow hole further up the tubing of the instrument (toward the mouthpiece). This hole, when open, splits the air column and effectively causes the instrument to sound a 12th above its fundamental register for any given fingering in the chalumeau register (though tuning is not always perfect). The key responsible for opening and closing this narrow hole is termed the speaker key. On Denner's early clarinets however, the functional speaker key (probably either one of the two new keys Denner added to the chalumeau) was placed too far down the length of the instrument (toward the bell). Additionally, the hole which the speaker key covered was far too large to split the air column and allow for effective overblowing.

After Johann Christoph Denner's initial invention of the clarinet, further advances were made by his son Jakob Denner. To allow the clarinet to overblow more effectively, Jakob Denner placed the speaker key (of the two original keys, the one on the underside of the instrument) higher up on the instrument and made the diameter of the speaker tone hole significantly smaller. In addition, Jakob Denner introduced the placement of a small metal tube protruding from the speaker hole into the bore of the instrument to prevent the draining of condensed moisture through that hole. He was also responsible for reducing the size of the mouthpiece and reed (also allowing for better overblowing capability). The very first clarinets by J.
C. Denner retained the very wide and thick reeds and wide mouthpiece of the chalumeau. Jakob Denner also devised a significantly larger bell, a feature which enhanced the aesthetic appearance of the instrument but also improved its projection of sound (Grove 328). Precisely when these improvements were made is not known. That they took place before 1721 is supported by a description of the clarinet from F. Bonanni's Gabinetto armonico, which accurately describes Jakob Denner's improved instrument:

An instrument similar to the oboe is the clarone. It is two and a half palms long and terminates in a bell like the trumpet three inches in width...There are in addition two other holes opposite to each other, but not diametrically.

(Rendall 70)

A further description of an extant specimen of a two-key clarinet by Jakob Denner reveals the following characteristics. This instrument is made of European boxwood, by far the most common material used in the construction of early modern clarinets (Rice 45). Its length measures 54.4 cm while its bore (the diameter of the inner tube) measures 14 mm at the barrel joint just below the mouthpiece and 14 mm in the lower joint just before the bell begins to flare (Stubbins 143). The instrument is made of four joints: 1) a combination mouthpiece and bulging socket (or barrel) joint, 2) an upper-joint containing the two keys and four tone holes for the upper hand, 3) a lower-joint containing three of the four tone holes for the
lower hand and 4) a combination bell and $F^3/C^5$ tone hole joint. Although several other specimens from the early 18th century are made of only three joints, the four joint clarinet soon became the standard of construction. Even today, this standard remains; the only significant alteration, the separation of the mouthpiece and barrel, occurred sometime during the late eighteenth-century (Grove 393).

Incidentally, Bonanni's description of the clarinet may be the first known source to refer to the new instrument developed by the Denners as a clarone (the origin of the term clarinet), a term which is derived from the Italian term clarion, meaning trumpet. Although it is not known who named the instrument, it was undoubtedly termed as such for the fact that it was thought to have sounded much like a trumpet. J. G. Walther, in his Musikalisches Lexicon of 1732 says of the clarinet, "from afar the instrument sounds not unlike a trumpet (Rice 44)". In addition, J. E. Altenburg, in the late eighteenth-century, stated:

The strident and piercing sound of this instrument is most useful in the military music of the infantry; and it sounds much better from afar than close to. (Kroll 24)

In addition, much of the music written for the clarinet at the beginning of the eighteenth-century uses a style similar to that used for the trumpet: fanfare motifs, repeated notes, and incomplete arpeggios (Rice 44). Also, up until the late
eighteenth-century, the clarinet sounded rather poor in its low (chalumeau) register and was thus almost always scored by composers to be played in its high (clarion) register, the tone quality of which more closely matched the tone quality of the trumpet than that of the chalumeau register.

Today, we typically do not think of the clarinet as sounding like a trumpet, and it may seem odd that this could ever have been the case. Part of the reason for this may lie in the fact that the clarinet during the eighteenth and early nineteenth century was played exclusively with the reed against the upper lip (a continuation of the traditional style of chalumeau playing). This technique made the tone quality of the instrument sound brighter (and much more like a trumpet) than that of an instrument played with the reed on the lower lip. In addition, the mouthpiece of the early clarinet was cut in such a way that there was absolutely no table for the reed to rest on. This forced the player to take a large portion of the reed and mouthpiece in his or her mouth because of the need to force almost the entire reed to vibrate. Moreover the reeds used were rather small and unusually stiff, much more so than the reeds used by today's clarinetists, thus increasing the probability of a loud and raspy sound. Finally, because it was a new instrument and, like the chalumeau, mostly played by peasants, the clarinet was not taken as seriously at first by professional musicians as more refined instruments such as the oboe and bassoon. Thus the skill of early players of the clarinet probably did not live up to lyrical capability of the somewhat
crude instrument. With all of the above factors taken into consideration, the sound emitted from such an instrument and by such players was no doubt not of the lyrical variety associated with the clarinet today but instead closer to the descriptions posed by Walther and Altenburg.

One minor setback caused by Jakob Denner's replacement of the speaker key was that the clarinet was temporarily left unable to voice a written B⁴. To solve this problem, a third key was added to the low end of the instrument enabling it to play not only an E³, but also, using the speaker key, the B⁴ a 12th above the fundamental. Although it is not known for certain who was responsible for this addition, it is generally regarded to have occurred by about 1740. Rendall claims that this addition actually took place no later than 1730 and may be attributed to one of J. C. Denner's sons (72). In its original form the E³/B⁴ key was accessed by the lower hand thumb (either the right or left hand thumb since hand positions were still interchangeable). This new key was soon moved to the top of side of the instrument and designed to be controlled by the left hand fifth finger which was now forced to take its position above the right hand. The positioning of the E³/B⁴ key has effectively determined the respective positions of the right and left hands for all time (Rendall 72).

It should be mentioned at this point that although the Denners seem to have been responsible for all significant innovations concerning the clarinet up until this point, many other instrument makers, beginning only very shortly after the
invention of the clarinet, were busy building quality clarinets of their own make. Of the extant clarinets from the early eighteenth-century, the largest body of makers and specimens are from Germany, with a total of seventeen two-key clarinets and five three-key clarinets by makers such as Gottlieb Crone (Leipzig), Johann Wilhelm Oberlender I and II (Nuremberg), Georg Heinrich Scherer (Butzbach), and Georg Walch (Berechtesgarten). Of these makers, Georg Heinrich Scherer has the most extant instruments to his credit, with six two-key clarinets and one three-key clarinet. Other extant clarinets from the early eighteenth-century include specimens from Belgium, the Netherlands, Austria, Czechoslovakia, and several from unknown origins (Rice 39-40).

The next significant step in the development of the clarinet was the addition of the $Ab^3/Eb^5$ and the $F^{#2}/C^{#5}$ keys to the lower joint. The $Ab^3/Eb^5$ key was originally placed on the underside of the instrument to be controlled by the right hand thumb but was soon replaced atop the instrument to be controlled by the right hand fifth finger; the $F^{#2}/C^{#5}$ key was placed next to the existing $E^{3/B^4}$ key and like it was controlled by the left hand fifth finger. Although Barthold Fritz, an organbuilder from Brunswick and Joseph Beer, one of the great Classical clarinet virtuosi, are both cited as possible inventors of the five-key clarinet, there is no conclusive evidence to support either claim (Kroll 19).

The development of the five-key clarinet, perhaps surprisingly, did not take place until as late as 1760, in the
early Classical era (1750-1820) and long after the development of the three-key clarinet. There are primarily two reasons for this. First, because the pads on the keys of early clarinets were no more than square pieces of felt triggered by weak springs, air leaks were a common problem. Thus, the general attitude during the eighteenth-century was that the addition of keys was something to be avoided (Brymer 29). Second, the clarinet, did not gain prominence as a standard orchestral instrument in Europe until about 1780 (Pino 204). Thus, technical improvement of what was primarily still a peasants horn until the last quarter of the century was not considered a priority.

Despite the lack of or desire for more chromatic keys on the clarinet during the Classical era, it is extremely important to note that players of the clarinet at this time did have the facility to play a nearly complete chromatic series through a combination of normally fingered tone holes, keys, and numerous cross fingerings. In addition, clarinets of various tonalities were built to facilitate the ability to play in almost any key. In the Classical era, this typically meant alternating between either instruments pitched in Bb and A or C and B natural. Rather than using completely separate instruments, however, performers simply placed alternative top joints of differing lengths called pièces de rechange on the body of either the Bb or C clarinet (Grove 393). Although this system created minor intonation problems, it made the use of the instrument simpler and more economic.
Because of the clarinet’s rise to prominence during the middle of the Classical era (largely due to the efforts of Gossec in France and Johann Stamitz in Germany during the early part of the Classical era), many new experiments were carried out on behalf of the instrument at this time. Though its inventor is unknown, the basset horn became a very popular member of the clarinet family in the late 18th century. The instrument was pitched in low F and could play as low as a written C\textsuperscript{3}. It was particularly favored by Mozart who appreciated its dark and mysterious tone quality and wrote significant parts for it in several of his later works including Die Zauberflöte and the Requiem (Brymer 35). Anton Stadler, a Viennese virtuoso, invented, for his own use, what can be called a basset clarinet. Although no original specimen of such an instrument survives, its existence is affirmed by the great Mozart Clarinet Concerto (written in 1791), the original solo part of which, although written for an instrument pitched in A, extends down to a written C\textsuperscript{3}, a range which could only have been accomplished by the basset clarinet (Brymer 36). Primitive bass clarinets were also devised during the Classical era although their use did not become significant until the late Romantic era, particularly in the music of Wagner (Pino 204).

Despite the experimentation in range of the clarinet provided by the Classical era, there were still some major basic acoustical and mechanical faults in the clarinet’s construction which were increasingly in need of being resolved. These were problems which could not be corrected by simply adding more
keys. Yet no maker seemed willing to make significant improvements until Iwan Müller began revolutionizing the instrument in 1808. Before this took place, several more keys were added to the existing five-key clarinet in attempts to answer the increased technical demands of performers and composers alike. Most significant of these new keys was the C#⁴/G#⁵ key added by Parisian clarinet virtuoso Jean Xavier Lefèvre circa 1790 (Grove 395). Simiot of Lyons also added the A⁴−B⁴ trill key which remains with us today. Keys added by other makers at this time are of less significance for the fact that they did not survive the acoustical and mechanical changes instituted by Müller.

Before discussing Müller's achievements in detail, other earlier innovations of Simiot of Lyons deserve attention. Simiot's advances can be seen in a surviving specimen from 1808. This instrument has a speaker key which, while still being controlled by the left hand thumb on the underside of the instrument, wraps around to the top side of the instrument where its tone hole lies; this position precludes the possibility of moisture blockage (Grove 395). This specimen also displays larger tone holes and a larger bore than earlier instruments (15 mm), revealing perhaps the first instance of acknowledgment by a maker of the relationship between these factors and the acoustical quality of an instrument.

In 1812 Iwan Müller presented a new clarinet to a review committee at the Paris Conservatoire. Although this instrument would soon prove to be the most significant advance in design
since the invention of the clarinet, it was swiftly rejected
approval by the committee members. The main criticism on the
part of the committee did not concern any specific features of
Müller's clarinet (no doubt they were forced to realize the
ingenuity that went into its production). Rather they were
concerned that this instrument (which could play in almost any
key), if endorsed, would eliminate the spectrum of timbres
available to the composer through the then current use of
clarinets of varying pitch levels.

Müller began restructuring the clarinet by, above all
else, insisting on the acoustically ideal placement of all tone
holes including those accessed by keys. Previous clarinet
manufacturing methods had left the matter of tone hole placement
to the standard of mechanical simplicity and fingering
convenience. Having found the ideal acoustical placement for
all tone holes, he then devised a fingering system to conform to
this acoustical standard. In doing this, he was careful, as he
states in his treatise:

...not to do anything which might interfere with the
former use or technique; all previously familiar
fingerings have not only been preserved but, so far as
seemed possible, applied.

(Kroll 26)

This concern on the part of Müller is certain to have
contributed to the success of his instrument, as players are
always reluctant to make any changes in equipment, no matter how
small.
Clarinet with as many as thirteen keys had already been devised by the time Müller introduced his instrument. Although some progress had been made over the poor sealing ability of the keys and pads on the clarinets of the Classical era, no significant improvements had been made. Here Müller again lead the way by fitting his new thirteen-key clarinet with rounded key cups fitted with round leather pads stuffed with cotton. In addition each key tone hole was countersunk and presented a raised and beveled ring to the pad, adding to the mechanism’s sealing ability (Weston, Clarinet Virtuosi of the Past 156).

One of the most significant features of Müller's advanced thirteen-key system was its introduction of alternative fingering branches for the F#³/C#⁵ and Ab³/Ab⁵ keys (both of which retained their original positions). These alternative branches were extended to be accessed by the right thumb which was still momentarily exempt from its current duty of supporting the instrument with the thumb rest (Stubbins 156). Later the principle of alternative fingerings would be applied more successfully to the Boehm system clarinet. A complete description of the fingerings for Müller's thirteen keys follows:

<table>
<thead>
<tr>
<th>Key</th>
<th>Fingering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. E³/B⁴</td>
<td>5th finger, left hand</td>
</tr>
<tr>
<td>2. F#³/C#⁵</td>
<td>5th finger, left hand and right thumb</td>
</tr>
<tr>
<td>3. F³/C⁵</td>
<td>5th finger, right hand</td>
</tr>
</tbody>
</table>
4. $Ab^3/EB^5$ 5th finger, right hand and right thumb
5. $Bb^3/F^5$ 4th finger, right hand
6. $B^3/F#^5$ 5th finger, right hand
7. $C^#^4/G#^5$ 5th finger, left hand
8. $Eb^4/Bb^5$ 4th finger, left hand
9. $F^4/C^6$ 2nd finger, right hand
10. $G^#^4$ 2nd finger, left hand
11. $A^4$ 2nd finger, left hand
12. $A^4/B^4$ trill 2nd finger, right hand
13. speaker left thumb

(Kroll 26-27)

Other significant contributions Müller made include the invention of the screw type metal ligature and the use of reeds which were thinned at the tip (Pino 207, 208). He also was one of the first clarinetists to advocate the practice of playing the instrument with the reed facing the lower lip (Kroll 29). Others soon followed Müller’s lead in this respect. In 1831, the Paris Conservatoire officially changed to the reed-below position, and important pedagogues such as Carl Baermann adopted this method. Despite the clear advantage of the reed-below position, however, many players in England for decades and in Italy well into the 20th century retained the reed uppermost style of playing (Weston, "Italy's Bel Canto Clarinetists" 44).

Although the Conservatoire’s rejection caused a brief setback for Müller and his innovations, it was only a matter of a few years before J. B. Gambaro and Frédéric Berr, the greatest
Parisian clarinet virtuosi at the time, were using clarinets based on Müller's design (Kroll 26). In addition, soon the best clarinet makers in Europe such as C. Bischoff (Darmstadt), Schott (Mainz), and Simiot of Lyons began adopting the Müller system, adding only minor refinements to the already satisfactory system. One of such refinements was the development of roller keys between the F\textsuperscript{3}/C\textsuperscript{5} and Ab\textsuperscript{3}/Eb\textsuperscript{5} keys of the right fifth finger and the E\textsuperscript{3}/B\textsuperscript{4} and F\#\textsuperscript{3}/C\#\textsuperscript{5} keys of the left fifth finger, an innovation which eliminated the need for the thumb branch keys devised by Müller. This invention is said to have been accomplished in c. 1823 by the instrument maker C. Janssen (Pino 209). The development of the roller key may have been fueled by the addition at some point during this time of the thumb rest, which must have made accessing the thumb branch keys extremely awkward.

A brief discussion of advances in mouthpiece design and construction during the nineteenth-century is also of importance. Not until its separation from the barrel was the mouthpiece considered a separate entity. Thus it was initially constructed of the same material as the rest of the clarinet (typically boxwood). By the early nineteenth-century experimentation had begun with the use of various materials including hard woods, glass, metal and ivory in the construction of mouthpieces. Simon Hermstedt, one of the great early Romantic period virtuosi, is known to have used a mouthpiece with a metal lay, which prevented warping of the lay normally associated with wooden mouthpieces. Towards the end of the
nineteenth century, ebonite (hard rubber) was introduced as a workable material in the construction of mouthpieces and its popularity grew rapidly. Today, ebonite along with plastic represent the most popular materials (NGDMI 297).

The design of mouthpieces also underwent significant changes during the nineteenth-century. Mouthpieces of the eighteenth and early nineteenth-century were extremely small, often with a profile no larger than a modern bassoon reed. In addition, these mouthpieces continued to be open down the entire length of the lay. With the acoustical reworking of the clarinet's body instituted by Müller and later Klosé and with the rising popularity of reed downward style of playing, a major change in the design of the mouthpiece was inevitable. Gradually, mouthpieces became larger, wider, and had longer lays to accommodate larger and longer reeds (Kroll 29). Throughout the 19th century, however, little attention seems to have been paid to the vital curvature of the lay towards the tip of the mouthpiece (which has a major effect on a reed's ability to vibrate). It was not until the twentieth century that makers began to research and design mouthpieces with this feature.

After Müller's innovations, the next significant step in the history of the modern clarinet took place in 1843 in Paris with the development of the Boehm system. Though this system is named after Theobald Boehm, the inventor of the modern flute, and based on some of his principles, the invention of the Boehm system clarinet was a result of a collaboration between Hyacinth Éléonore Klosé, clarinet professor at the Paris Conservatoire
from 1839 until 1868, and Louis-Auguste Buffet, a Parisian instrument maker. Klosé and Buffet, in the same manner as Müller, set out as a matter of first priority to place the tone holes, in spite of fingering convenience, where the laws of acoustics demanded they be placed (Stubbins 161). They also paid special attention to the size of tone holes, discovering as they did that progressively larger tone holes down the length of the instrument produced a more acoustically desirable result.

To complement their new advanced tone hole system, Klosé and Buffet sought to create a fingering system which would exceed the technical capabilities of contemporary Müller system clarinets. Part of this advance was in the application of rings (used by Boehm on his flutes) to the clarinet. A ring is, as its name implies, a ring which rests above a fingered tone hole. When the tone hole is covered by the finger, the ring is simultaneously depressed, causing its pad to cover a different tone hole at another location. Although other attempts to apply the principle of rings to the clarinet had taken place as early as 1808 (Kroll 31), The Boehm system represents the first successful application of this principle to the clarinet.

Klosé and Buffet also advanced Müller's original principle of alternative key branches by creating both left and right hand fifth fingering branches for the keys covering the $E^3/E^4$, $F^3/C^5$, and $F#^3/C#^5$ tone holes. This advance eliminated, in most cases, the need to glide from one key to another, as with the Müller system. The ring principle also created alternative fingerings
for $B^3/F^\#^5$ and $Eb^4/Bb^5$ as well as eliminating the need for cross (or forked) fingerings.

The final version of the Boehm clarinet, which Klosé and Buffet presented in 1843 as clarinette à anneaux mobiles (clarinet with movable rings) had a total of twenty-four tone holes, seventeen keys and six rings. It is a remarkable testament to the sensibility of this system that not only has it grown to become by far the most popular system in world today but also that no significant alteration to the first model of 1843 has contributed lasting effect to its fundamental design. Initially, there were however, several attempts to alter and improve Klosé and Buffet's design. These will be discussed in detail once further improvements on Müller's clarinet have been described.

The creation of the Boehm system clarinet by no means made the Müller system obsolete. The Müller was and remains even today a good basic system. In order to keep up with the technical demands of professional players and composers and ultimately compete with the versatile Boehm system, however, its technical potential needed to be enhanced through the addition of several new keys. At about the same time as Klosé and Buffet were developing their system (c. 1840), Adolph Sax in Belgium applied the principle of rings to the lower joint of the Müller system clarinet which among other things, improved the intonation of $B^3/F^\#^5$. This addition has had a lasting effect and can be seen on the present day Oehler system German clarinet.
Fellow countryman Eugène Albert also employed rings on the lower joint of his refined Müller system clarinet as well as moving the speaker tone hole around to the top side of the instrument (Rendall 110-11). Albert's three sons, Jacques, J. B., and E. J. carried out further refinements of the Müller system. The Albert family's instruments, with respect to intonation and overall quality of construction, rank among the finest ever produced and are noteworthy for the immense popularity they gained both in German speaking countries and England during the middle and latter part of the last century. In the face of the growing popularity of the Boehm system throughout Europe, this surge of popularity was important in assuring the Müller system's survival into the twentieth century.

A further improvement upon the Müller system, presumably the work of a French maker during the middle of the nineteenth-century, was the addition of a special mechanism to enable the Müller clarinet to smoothly trill from E₃ to F#₃ in the chalumeau register and from B⁴ to c#⁵ in the clarion register (Kroll 33). This mechanism is of special value in comparison to the Boehm system which has no efficient means of moving rapidly between these notes.

Carl Baermann made additional improvements to the Müller clarinet around 1860 (Rendall 110). In collaboration with the maker Georg Ottensteiner, Baermann improved the instrument by making it possible for most notes on the instrument to be played in at least two different ways, either through auxiliary levers
or new keys. Specifically, the following improvements were made: 1) an additional lever for the right first finger was added to the C#⁴/G#⁵ key, 2) both the third and fourth fingers of the left hand, as well as the right index finger were enabled to control Eb⁴/Bb⁵, 3) a new lever enabled the fourth finger of the left hand to open the F⁴/C⁶ key, and 4) a new key for Bb³/F⁵ was designed for the fifth finger of the left hand. In addition, Baermann and Ottensteiner added ring mechanisms to correct the notes F#⁴ and B³/F#⁵ on the upper joint (Kroll 36).

Baermann's improved Müller clarinet was a great success in Germany where its use was at least partially prompted by the fact that Baermann based his famous instruction book on it. The Baermann System's users includes the famous Richard Mühlfeld, the clarinetist for whom Brahms wrote his great clarinet masterworks late in life. Additional refinements at the end of the nineteenth century to the Müller clarinet, which at this point we may begin calling simply the German clarinet (for its continual decrease in popularity in non-German speaking countries at this time), were made by a number of German makers including Robert Stark, Wilhelm Heckel, Georg Grässel, and Ernst Schmidt. The most ingenious and lasting contributions after those of Carl Baermann to Müller's original clarinet, however, were provided by Oskar Oehler of Berlin, the creator of the modern Oehler system German clarinet. His contributions will be discussed briefly.

As was shown previously, the story of the development of the modern Boehm clarinet has, in a sense, already come to an
end with the account of its introduction in 1843. In fact the only major difference between the model of 1843 and the model most commonly employed today is a minor reduction in the size of tone holes (for better intonation), a slight increase in the size of touchpieces for keys (Rendall 106-107), and a more extensive application of the needle spring (NGDMI 397). Still, during the nineteenth century, the spirit of mechanical innovation prevailed and many makers attempted to improve the plain Boehm system or apply its principles to other existing systems.

The so called full Boehm clarinet appeared some time after the introduction of the simple Boehm system in 1843. The instrument is properly named for as Stubbins states, "as a mechanical system of fingering, the full Boehm represents the final development in mechanical dimensions of the boehm system (Stubbins 167)". An extant specimen of such a clarinet in Bb by the maker Buffet includes the following additions: 1) an extra key for Eb\(^3\)/Bb\(^4\) located below the right fifth finger key cluster (which enables the instrument to match the range of a clarinet pitched in A and thereby transpose its parts under all circumstances), 2) an articulated C#\(^4\)/G#\(^5\) key (enabling this key to be held down during rapid passage work for greater fluidity), 3) a forked Eb\(^4\)/Bb\(^5\) on the upper joint, and 3) an alternate Ab\(^3\)/Eb\(^5\) key for the left fifth finger (Stubbins 167). The full Boehm clarinet gained some degree of popularity in the last century; the Spanish clarinetist Manuel Gómez, who was influential in promoting the Boehm system clarinet in England
beginning circa 1890, played on such an instrument (Pino 217). In addition, the full Boehm system became popular in Italy, where it is still used to transpose parts written for clarinets in A on the Bb instrument. Despite its technical advantages, the full Boehm system is more mechanically unreliable and significantly heavier than the simple system; these factors in part account for its present day unpopularity.

The Spanish clarinetist Antonio Romero y Andia, upon his appointment to the Real Conservatorio of Madrid in 1849, introduced the Boehm clarinet to that country. By 1853, however, he presented a design to French makers which sought to improve the technical capability of the instrument, particularly its ability to cross the break (between the chalumeau and clarion registers). It wasn't until 1862, however, that Romero found a maker willing to carry out his instrument's extremely complex mechanical design. The finished product was truly an ingenious piece of workmanship. Romero enabled his instrument to cross the break more efficiently by transferring control over certain throat tones (the highest four semitones in the chalumeau register) from the left hand to the right. In addition the instrument's overall intonation was far superior to its contemporary Boehm cousin. Although the Romero system represents perhaps the furthest mechanical advance in clarinet design at any time, its success was only short lived due to mainly two factors: 1) its mechanical complexity caused a greater degree of unreliability and 2) its use required learning a significantly different finger system. Interestingly,
Mahillon, a noted Belgian maker of improved Müller system clarinets, developed an instrument remarkably similar to the Romero system, though with no knowledge of the latter's existence (Rendall 108-109).

No mechanical challenge seemed too great to overcome (or at least attempt to overcome) for instrument makers during the last half of the nineteenth-century. Perhaps the greatest of these challenges lay in creating a single instrument which could eliminate the clarinetist's need to alternate between clarinets of varying lengths. The first of such combination clarinets, as they are termed, was actually built as early as 1808, when the inventive Simiot of Lyons built a clarinet in C with no less than ten separate extension joints to be added (equally spaced along the length of the instrument) and transform it to a clarinet in Bb (Pino 214-215). Although this system provided better tuning than the use of pièces de rechange, it was far too complex for practical use.

In 1862, L. A. Buffet presented a more mechanically advanced combination clarinet. It consisted of two metal tubes, one inside the other. Each key and ring on the outside affected both the tone holes of the shorter inner tube pitched in Bb and the longer outer tube pitched in A. A turn of the bell would alter the alignment of the tone holes and cause only either the inner or outer tube to be activated. Despite the practicality and mechanical ingenuity of the instrument, it proved unusable due to major intonation problems (Pino 215). Other combination clarinets of different designs were introduced in Italy and
Germany (Kroll 38-39); none of these, however, proved able to compete with the purer intonation and tone quality of regular clarinets.

A further step in meeting the technical demands of composers is evident in the rare and fascinating production of quarter tone clarinets. In Berlin, Dr. R. H. Stein designed a quarter tone clarinet in 1911 which was basically a normal Bb instrument with a number of added quarter step keys. A more complex design by Fritz Schüller of Markneukirchen consisted of two side by side tubes of slightly different lengths joined at the top by a single barrel and mouthpiece the former of which had a valve to direct the airflow into either the shorter or the longer of the two tubes (Kroll 45). These instruments, as might be expected, were of passing interest to clarinetists as well as the rest of the musical world.

Two fairly recent mechanical innovations in clarinet design are worth noting. The first is the so called S-K mechanism named after its co-inventors, William Stubbins and Kalmus, who were issued a U. S. patent for the mechanism in 1952. With both regular German and Boehm system clarinets, the speaker key is made to act at different times as both an overblow tone hole and as a Bb⁴ tone hole. Because the ideal designs for meeting these two duties of the speaker key are at odds with one another, neither design can be satisfied completely, and a compromise must be made. In practical terms, this means having an instrument with a fuzzy sounding Bb⁴ and a speaker key which provides only barely adequate overblowing
capability. The S-K mechanism solves this problem by eliminating the need for one hole to act as both a speaker key and a tone hole. Mechanically, this effect is achieved as described by Stubbins himself:

The S-K mechanism provides an additional resonance hole, which is opened when B♭ third line is played in the conventional manner with the speaker key and the A key. This additional resonance aperture supplements the size of the speaker aperture in such a way that the same aperture size for the production of this B♭ is available, as when the side trill key is used as an alternate fingering. In addition, by the ingenious connection of this resonance hole key to the action of the thumb ring, the resonance hole is closed, and the new smaller size speaker aperture is allowed to freely produce the twelfths of the second vibrational mode scale, in a more proper manner than heretofore. (171)

Although the S-K mechanism is applicable to both Boehm and German system clarinets, its production has so far been limited to a model by Noblet made shortly after the mechanism's debut. Indeed, although Stubbins (in 1965) was confident that the S-K mechanism would become a standard addition to at least Boehm system clarinets, this has not been the case.

A second recent mechanical innovation by Rosario Mazzeo replaces the normal throat tone fingerings of the Boehm system with new mechanisms which allow the throat tones to be activated by the rings of either joint. This arrangement allows for greater technical facility in rapid passages involving these notes. The Mazzeo system also includes a mechanism to allow for smooth transfer between the B⁴ and C#⁵, the lack of which has
always been a major disadvantage of the Boehm system (Brymer 55). The Mazzeo system, despite its improvements of the Boehm system, has also failed to become very popular.

If the Boehm clarinet is the definitive clarinet of most Western nations, then the Oehler system is its equivalent in German speaking countries. The Oehler system represents the furthest advances upon the Müller clarinet of 1812 and was gradually developed over a period of several decades beginning around 1890 by Oskar Oehler, who gave up a performing career as a clarinetist to devote his energy to the improvement of the Müller system (Fino 217-218). Brymer says of Oehler's work:

...[he] altered the position and shape of almost every key, adding an extra vent-hole here and bridging an awkward touch-piece gap there until the instrument was tailored to the hand of the player, and as acoustically perfect as it could be made.

(49)

In the end, Oehler created a clarinet with twenty-two keys, five rings, and one finger plate, an instrument considerably more mechanically complex than the Boehm system. This complexity, despite its greater degree of unreliability, does give the Oehler system the advantage of truer intonation over the Boehm system. On the other hand, this complexity makes the Oehler clarinet more difficult to finger (especially because of its retention of roller keys). In the end there are certain advantages and disadvantages that go with selecting either the Boehm or the Oehler system. No one system can be said to be
decidedly superior to the other (although many would make this claim).

The coexistence of the Boehm and German style clarinets since the middle of the 19th century has not solely been based on a dichotomy over the proper mechanics of the clarinet. Rather, the Boehm and German systems each reflect separate schools of clarinetistry which have come to hold their own distinct view of what the clarinet is and what it should sound like. Even before there was any significant difference in the instruments used by the French and the German schools, two distinct approaches to the proper sound of the clarinet were taken. In comparing the Classical era virtuosi Joseph Beer and Franz Tausch, Weston writes:

The two clarinetists created completely dissimilar styles of performance. Beer spent the prime of his life in Paris and founded the French style, which featured brilliance and volubility. Tausch trained in the Mannheim orchestra and developed the beauty and nuances of tone which became the characteristic of the German school of playing.

(Clarinet Virtuosi of the Past 29)

The cultivation of the German and French schools continued throughout the Classical era into the Romantic, each school growing further apart from the other in its approach to the clarinet. Soon this dichotomy began to be reflected in the physical characteristics of the instruments employed by the two schools. Nowhere is this more visible than in the design of the mouthpiece and reed, both of which greatly affect the sound of
the instrument. During the nineteenth century, mouthpieces used by French clarinetists gradually became larger and wider, while the reeds became thinner. German mouthpieces, on the other, although also becoming wider, always remained narrower than their French equivalent; the reeds of the German clarinetists also remained significantly stiffer and narrower than those of the French. In addition to the mechanical differences on the bodies of each school's respective clarinet, there was and continues to be a slight difference in their size of bore, with the German clarinet leaning more towards conservative dimensions.

Both the German and French schools of today have changed very little in their individual concepts of sound. The German sound is still typically described as being dark, round and compact, while the French sound remains bright, clear, fluid, and somewhat edgy. One must realize however, that both the French and German sounds are achieved only partially through the physical aspects of the player's instrument. More important is the training and intention of the player who constantly manipulates his or her sound to the desired aesthetic effect.

Several conclusions are supported by this history of the clarinet. First, the process described as the evolution of the clarinet is properly termed, for the instrument as it appears today is the sum of a collaborative effort between artists and builders throughout the past three-hundred years. Second, the rate of this evolution has been influenced by primarily four factors: 1) the clarinet's acceptance as an instrument worthy
of sponsorship (an influence which greatly restricted its evolution during the first century of its existence), 2) the ingenuity of particular makers as well as the overall technological skill of his or her particular era (in the nineteenth-century a great degree of both help contribute to the instrument's rapid evolution), 3) the ever increasing technical demands of composers, and 3) the ability and/or willingness of players to adapt to changes in the design of the instrument, a factor which has perhaps slowed certain mechanical advancements but has assured the integrity of the clarinet's overall evolution.
Notes

1 An instrument with a cylindrical bore has an inner tube with a diameter that remains constant down its entire length.

2 Although Brymer suggests that Johann Christoph Denner, the supposed inventor of the clarinet, was actually responsible for this new mouthpiece design (22), no other sources lend support to this claim.

3 All clarinets, regardless of length, use the same fingering for any given written pitch. The actual pitch produced, however varies according to the length of the instrument. Thus a clarinet pitched in Bb when fingering a C will produce a Bb in actual (concert) pitch, while a clarinet pitched in C (somewhat shorter than a Bb clarinet) when fingering a C will produce a C in concert pitch. This system allows the player the convenience of avoiding the need to transpose parts in his or her head according the length of the instrument being used. It also, however, means that a written pitch must be transposed on paper according to the length of the instrument to produce the correct concert pitch.

4 An exact date for the invention of the clarinet remains elusive. Although Doppelmayr himself asserts that the clarinet was invented sometime in the beginning of 18th century, other researchers have suggested that the probable date of its
invention is 1690 (Stubbins 142). Other estimates (of which there are many) fall somewhere between these two extremes.


