

**PECULIARITIES AND ANOMALIES OF INTONATION
WITH SPECIAL REFERENCE TO THE
CONSTRUCTION AND EVOLUTION OF WOODWIND
INSTRUMENTS**

By

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ABSTRACT

PECULIARITIES AND ANOMALIES OF INTONATION WITH SPECIAL REFERENCE TO THE CONSTRUCTION AND EVOLUTION OF WOODWIND INSTRUMENTS

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The author has been playing principal flute for almost twenty years, in the "G. Enescu" Bucharest Philharmonic Orchestra, the Cape Town Symphony Orchestra and the Cape Philharmonic and was fortunate to hear live some of the leading world orchestras, among them the Berlin Philharmonic, Vienna Philharmonic, Gewandhaus, London Philharmonic, London Symphony, Orchestre Nationale de France, New York Philharmonic, Chicago Symphony and the Boston Symphony.

All these great orchestras experienced intonation problems, mainly in the woodwind section, and I have started to study this phenomenon, which has followed me through my entire life.

Over the centuries, woodwind instrument makers have tried to facilitate the playing and to improve the intonation of each instrument. To understand better the intonation of the woodwind instruments it was necessary to write a short history of each instrument's evolution, from a keyless instrument to the complicated "too-many-keys" modern instrument. On preparing this thesis the author has also visited some museums where rare old instruments can be seen, among them the Paris Conservatoire Museum, the Brussels Conservatoire Museum, Musée des Arts et Métier, Paris, the Vienna Conservatoire Museum, the Prague Conservatoire Museum, the Dresden Conservatoire Museum, the British Museum and the Royal Academy of Music Museum, London.

After describing each instrument's pitch anomalies and methods to improve it, the author explains the principal factors which influence the intonation.

This thesis, hopefully, will help the student, the teacher, the chamber musician, the orchestral player, the band director, the conductor, the sound engineer, the producer, and all musicians to understand better all peculiarities of the intonation of woodwind instruments.

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I am indebted to my former colleagues of the Cape Town Symphony Orchestra and the Cape Philharmonic for their help with their invaluable information I have been given of their instruments, respectively to John Rojas on oboe d' amore and cor anglais, Johan and Cathy de Doncker on clarinet, E flat clarinet and bass clarinet, Becky Steltzner on bass clarinet, Ingo Holland and Dieter Morschel on bassoon and Simon Ball on contrabassoon.

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ABBREVIATIONS USED

Contrary to piano fingering where the thumb represents the first finger, the notation for the woodwind instruments differs as the index represents the first finger. Mention should also be made that the bassoon is the only woodwind instrument which uses both thumbs (all other woodwind instruments use only the left thumb). Here is an explanation of the fingering symbols found throughout this thesis:

LH	= Left hand
T	= Thumb
LT	= Left thumb
RT	= Right thumb
LT B flat	= The thumb operates the B flat key
l 34/1 4	= Left hand first, third and fourth fingers/ Right hand first and fourth fingers.
LH1, 2, 3, or 4	= First, second, third or fourth finger of the left hand
RH	= Right hand
RH1, 2, 3, or 4	= First, second, third or fourth finger of the right hand
Tr	= Trill key
SK	= Speaker key

For the measurements of pitch a ZEN-ON chromatic and automatic tuning machine was used. The pitch unit is called a cent and represents one hundredth of a semitone. It takes five to ten cents alteration in pitch to make a perceptible difference in two successively played notes. There are subdivisions from 0 to + 50, and 0 to - 50 (e.g. F# -15 = the F# is fifteen cents too low).

When referring to the compass of each instrument the first note is numbered as 1 and not as in piano notation. For example the first C on the flute would be C1, corresponding to C4 on the piano; C3 represents the C above the stave. For the bassoon, capital letters are used from low B flat until the middle c, which is normally written in the treble clef. For the contrabassoon the octave below the bassoon B flat is marked with,, (e.g. D,, represents D one octave lower than D of the bassoon).

The charts of the transposing instruments (clarinets, cor anglais, oboe d'amore and alto flute) describe the written notes and not the sounding (concert) ones. For the concert notes refer to each instrument's transposition.

The Flute

No one knows how, when and where the flute was invented. Certainly it was developed many centuries before music was written down. Flutes of various sorts were known in ancient civilization. The Sumerians and the Egyptians played vertical flutes, and in the Old Testament an instrument called *ugâb* is mentioned. The oldest surviving Egyptian instruments date from the Middle Kingdom (2160-1580 BC). End-blown flutes of similar shape still exist today in the Islamic countries called *nâi*, and in the Arab Peninsula called *qasaba*.

The oldest transverse flute according to Sachs¹ in *The History of Musical Instruments* was a Chinese *ch'ih* dating from the ninth century. The next examples of early transverse flutes on art-works belong to the Roman civilisation. On a Roman coin from the Syrian town of Caesarea, dated from the year 169 BC, there appears a transverse flute, and in about 1960, excavations in the Tomb of the Volumni near Perugia revealed one of the most important of all musical remains regarding the flute. In an Etruscan tomb dated from the second and third centuries BC, an urn was found, which depicts in relief the head and shoulders of a man playing an instrument, which resembles to a transverse flute. The flute is held to the right as in modern flute playing; both hands are covering the finger-holes and a mouth-hole about one-quarter along the tube is clearly visible. That relief represents the oldest portrayal of a true transverse flute.

It is difficult to construct a continuous history of the ancient flute because the flute disappears from art works after the fall of Rome, and only reappears in the tenth and eleventh centuries. A plausible current theory is that the flute may have been introduced into Western Europe by the way of the Germanic lands from Byzantium. Certainly the transverse flute is depicted on a number of Byzantine art works of the tenth and eleventh centuries, as, for instance, on the wall paintings in the Cathedral of Kiev. From the same period there are ivory caskets, respectively in the Museo Nazionale, Florence and the Victoria and Albert Museum, both depicting transverse flutes on carving. The earliest Western Europe representation of a transverse flute came from the Germanic countries (probably that was the reason the transverse flute was called for centuries the German flute).

1. Sachs, Curt (b. Berlin 1881; d. New-York 1959). American musicologist of German origins. His most important works are the *Real-Lexicon der Musikinstrumente* (Berlin, 1913) and *The History of Musical Instruments* (New-York, 1943).

Examples of that period are an aquamanile (water-color paper) of c. 1100 now in the Budapest National Museum, Hungary and a miniature of three sirens, one of them playing the flute, from a twelfth century German Encyclopedia, the *Hortus Deliciarum*, compiled by the Alsacian abbess Herrard von Landsberg. The illustration can be seen in Alexander Straub's edition of 1901; the original was destroyed by fire in 1877. Another reference of the use of the transverse flute dates from the first decade of the fourteenth century, and can be seen in the Manesse Manuscript, a collection of Minnesinger texts, where, for the first time the flute can be seen in combination with the Medieval fiddle, playing Minnesänge.

During the fourteenth century the flute began to appear in non-Germanic countries as well. Transverse flutes are shown in the hand of Spanish court musicians, as seen in some illustrated manuscripts of *Cantigas de Santa Maria*, the anthology of music associated with the court of King Alfonso X the Wise, King of Castile and Leon (1252-1284), which dates from the late thirteenth or early fourteenth century, preserved in the Library of the Escorial. The flute is also depicted in some Franco-Flemish manuscripts, as for example, the *Books of Hours* of Jeanne d'Evreux, of c. 1320, belonging to the Metropolitan Museum of Art, New York, and the *Bellville Breviary*, both illuminated by Jean Pucelle; the manuscript of the *Romance of Alexander*, illuminated by Jehan de Gris in Flanders in 1244, now preserved in the Bodleian Library, Oxford. French poets also mentioned the flute in their poems. Among them Guillaume de Machaut¹ mentioned the *flaüstes traverseinnes* in a long list of instruments, constituting nearly a complete fourteenth century instrumentarium, which occurs in *La prise d'Alexandrie*.

The transverse flutes disappear from art works between the second and the last decade of the fifteenth century, probably because their use was not widespread, but from the end of the fifteenth and throughout the sixteenth century flutes are shown in pictures of various sorts and they are listed and described in many written sources, both literary and musical. Evidently, they had finally established themselves as standard instruments suitable for performances at courts and in chamber music of all kinds. Curt Sachs in his *Real-Lexicon* quotes a late fifteenth century source from Ferrara, that the transverse flutes were a novelty in Italy, where they were called *falauti alemani* (German flutes).

1. Machaut, Guillaume de (c. 1300-1377). French composer and poet. He is one of the most important figures of the French Ars Nova

Throughout the sixteenth century the flutes were a regular feature of the Italian musical life, as they appear in many Italian works of art and musical documents. In England the flutes were common by the sixteenth century as they are mentioned in Henry VIII's well-known music inventory (The Inventory of the Guarderobes, etc. preserved in the British Museum). The French also had a special regard for the flute. Pierre Attaignant, the famous Parisian publisher, active in Paris from 1520 to 1540, printed two volumes of chansons in 1533, some of which he recommended as being suitable for performance by consorts of flutes or recorders.

Very little is known about the construction of the Medieval flute, especially related to its size and how it was tuned, but pictorial evidence supports the theory that the instrument was built in very similar way as the sixteenth century flute. It had a cylindrical tube in one piece, with an embouchure hole and six finger-holes. Examples of sixteenth century flutes survived and can be seen in many of the major instrument collections in Brussels, Berlin, Verona and Vienna. The names of the instrument makers of the time are largely unknown, with the exception of the Frenchman Claude Ravi (? – d.1533), who worked in Lyons and was one of the most celebrated makers of the time.

During the sixteenth and the first half of the seventeenth centuries some very important treatises on musical instruments were published in Europe. The most important were *Musica Getuscht* by Sebastian Virdung¹ (1511); *Musica Instrumentalis deudsch* by Martin Agricola² (1528, 1532, 1542 and 1545) and *Syntagma Musicum* by Michael Praetorius³ (1618 and 1619). In Virdung's work only one transverse flute is pictured, with a rather badly executed woodcut. Its bore is very narrow in relation to the length; the holes appear to be too close together, and in fact could be a shrill, penetrating fife (the ancestor of the piccolo). Martin Agricola in 1528 gave some details about the flutes: he mentioned that they should be purchased in sets, in order to ensure that they were in tune with one another.

1. Virdung, Sebastian (? –died c.1565). German theorist and composer. His *Musica Getuscht* (Music, translated into German) represents the oldest printed manual on musical instruments, having also some of the most clear illustrations for its time.

2. Agricola, Martin (1486-1556). German music theorist, composer and teacher. His most important theoretical work was *Musica Instrumentalis*.

3. Praetorius, Michael (1571-1621). German composer and theorist. Volume II of the *Syntagma Musicum*, subtitled *De Organographia*, contains detailed drawings of all the instruments used in his time.

In his 1545 edition of the *Musica Instrumentalis*, there is an illustration of four flutes of different sizes (discantus, altus, tenor and bassus), but the text states clearly that only three of them were actually in use, with the range of two octaves upwards from G, D and A. Hence the middle-sized flute, that in D, played both alto and tenor parts in a four-part texture, and can be regarded as the direct ancestor of the modern flute. Praetorius, in 1619, described all three members of family and added that he had some instruments made in two joints, so the socket between the head-joint and the body could be used a tuning-slide. This arrangement can be considered the first attempt for intonation and pitch correction.

In the seventeenth and eighteenth centuries, France set the cultural fashion for the rest of Europe. Woodwind music in general, and flute music in particular, was appreciated at the French court. The first picture of a six-hole flute can be seen in a book by Marin Mersenne (1588-1648), *Harmonie Universelle*, published in Paris in 1637. Describing his flute as "one of the best flutes in the world", Mersenne provided some statistics: it was a cylindrical flute, tuned in D, the finger holes varied in size and to play in other keys the player had to use cross-fingerings, or only partially cover the holes. To be within reach of every size of hand, the E and A holes had to be cut above their true position and to correct the sound they were made smaller than the other holes. It is easy to imagine how difficult, if not impossible, it was to play in tune on this flute.

Some years later, around 1660, the flute gained a new hole, bored half way between the lowest finger-hole and the open end of the tube. Its purpose was to play D# (and its harmonics), previously obtained only by cross-fingering, and never really clear and in tune. It was the first time a key was introduced and it was manipulated by the little finger of the right hand. Another French improvement was to bore the flute conically, replacing the cylindrical bore, which had been characteristic of transverse flutes up until that time. This conical bore gave the flute a softer, more musically pleasing sound, much sweeter than the shrill, military-fife type of tone quality which had characterised the earlier transverse flutes with cylindrical bore. By this time the instrument was made in three pieces, a head, a body, and a foot and the holes were smaller than those described by Mersenne. The transverse flute with six finger holes and one closed key for D# was the standard orchestral flute from about 1660 to 1775, the one for which Bach, Haydn and Mozart wrote. Its conical bore, with a cylindrical head-joint, was developed by the Hotteterres, a family of French musicians and instrument makers who started their trade during the seventeenth century and had a profound influence on the design of many woodwind instruments.

Probably the most famous of them was Jacques Hotteterre (1674-1763), called "Le Romain" who published the first book of instructions, in any language, for the transverse flute. Its full title was *Principes de la Flûte Traversière, ou Flûte d'Allemagne, de la Flûte A Bec, ou Flûte Douce, et du Hautbois, Divisez en Traitez* and was published in Paris in 1707. Despite all these improvements, the intonation of the flute remained uncertain. One factor was the material from which it was made. At this time the most popular material was boxwood, which looks handsome and produces a mellow sweet tone. Boxwood, however, absorbs condensation readily, causes the wood to swell and puts the intonation out entirely. An alternative material was ivory, but its touch and texture were unpleasant to the player's lips. Intonation then depended on two things besides the material used. One was the exactitude in the making of the finger holes, the other the flute-player's talent. The use of large holes enabled the player to correct his intonation within quite broad limits, but the sharp and flat notes made by cross-fingering were very out-of-tune. After the invention of the D# key, flute makers began to reduce the size of the finger holes so that the intonation would be clearer and more precise.

Recognising some of the problems, Hotteterre in his *Principes* gave careful directions for "humouring" certain notes that might be sharp or flat by means of the lips, by turning the flute "in" or "out", or by using different fingerings. Judging from the measurements John Coltman¹ made on one key flute we can observe that they were all low in pitch compared to present standards. Their intonation corresponds to about A = 415. There was a general tendency for the French pitch during that period to be low. The pronounced falling off as the scale descends to the lowest register is typical of all these flutes. The extraordinary flatness of the F# must also be noted. A reason for such flattening was the desire to help somehow the extraordinary sharpness of the F natural, for which there was no fingering choice except a fork-fingering in which the hole below the F# hole was closed in an attempt to flatten the F#. The C#1 and remaining fork-fingered notes and the third register are also very sharp.

France gave rise not only to technical innovation but also to flute virtuosi and much music for the flute. Better flutes led to better players, whose performances encouraged composers to write more pieces. And this in turn prompted further improvements in the instrument. In 1726, Johann Joachim Quantz (1697-1773), the famous flute player and teacher of Frederick the Great, added an extra key to the flute, invented a tuning slide and brought a new precision to the stopper and the finger holes.

1. Coltman, John. (born 1926). American researcher for Westinghouse Research Laboratories. "The Intonation of Antique and Modern Flutes," *The Instrumentalist*, December, 1974, pp.53-55.

The extra key, side by side with the D# key, was intended to provide a distinction between D# and E flat, and also was to be used for enharmonic differences of some other notes, in fact improving all the sharps in the first octave and G# in the second.

But the problem of pitch once again arose. In the eighteenth century there was no specific term for pitch itself and performing pitch levels varied considerably. The pitch of organs varied in unheated churches between summer and winter, and metal pipes were liable to become frayed in time as a result of repeated tuning. It should be mentioned that the tuning was done by bending the top of the pipes, which eventually needed to be trimmed, thereby raising the general pitch by an indefinite amount. That was the reason that woodwind instruments were equipped with interchangeable joints of different lengths. Clearly it was necessary to have a flute capable of playing at whatever pitch was required. Flute makers before Quantz had tried to solve the problem by attempting to lengthen the joints in the various parts of the flute, so that extra wooden rings could be inserted between sections in order to lower the pitch. The trouble was that the pitch was lowered unequally. As wooden rings were fitted, the right hand finger holes moved increasingly out-of-tune with those of the left hand. Quantz used three to six different lengths of the upper joints (the middle joint was made in two pieces). Three upper joints was the most common provision, the shortest making the flute a semitone sharper than the longest. Quantz decided that something more effective had to be done about this unpredictable pitch and invented the tuning slide. By lengthening the pin of the pin-and-socket joint between the head of the flute and the first section of its body, he made it possible to lower the pitch by as much as a quarter of a tone. This did not solve everything, as with the pin lengthened to its full extent, the second and third octaves fell in pitch further than the first. Quantz knew very well that if one part of the flute was lengthened, the other parts should be adjusted in proportion.

The stopper (the plug that closes the head at the top end) plays a crucial role in tuning the flute. Its position had to be a compromise, and Quantz realised that if a tuning slide was to lower the pitch of the flute, the stopper could compensate as long as any adjustment of its position was minute. He set the stopper on a screw, which could be turned from the closed end of the flute to make all the precise adjustments, which would allow for the use of the tuning slide.

Observing the flute Quantz made for Frederick the Great (ca. 1750), one can notice that the flute is also low in pitch, with F natural still very sharp and F# very flat.

G and A in the first octave are very sharp, C#1 is sharp and the fork-fingered notes are quite out-of-tune.

In the last quarter of the eighteenth century, many makers sought solutions to the intonation problem, using a mechanical approach. Extra holes, provided with normally closed keys took the place of fork-fingerings, a technique which left many notes sounding uncertain. Holes were bored between E and F# to give F natural; between G and A to give G#/A flat; and between A and B to give A#/B flat. The one note which still required cross-fingering was C. Once the new closed keys for F, G# and A# were adopted - still without disturbing the traditional D major fingering pattern - the four-keyed flute rapidly displaced the one-keyed flute, thus setting the stage for the great nineteenth century woodwind design explosion.

Before that in about 1790 Tromlitz¹, a flute maker and player from Leipzig, invented the foot joint with added C# and C natural. In addition to making a note for C natural, Tromlitz began to rationalise the position of keys and their levers by designing keys, which could be used by either of two fingers in situations where one of them was required elsewhere. Before that, the same finger sometimes had to stop a hole and press a key in the same time. Actually, Tromlitz with London pioneers, Florio², Gedney³ and Potter⁴ made the six-keyed flute, which is none other than the common simple-system flute of recent times minus the upper C key and the long F key, which appeared as optional additions at the end of the century. The three upper joints were still often provided, though now less urgently needed.

In spite of Tromlitz's efforts, the flute was still a long way from perfection; the F# was still extremely flat relative to its neighbours, the C# was still very sharp, but there is an improved intonation because of the keys which replaced the fork-fingered notes.

1. Tromlitz, Johann Georg (1725-1805). German flautist, teacher and instrument designer. In 1754 he became first flautist in Grosses Konzert in Leipzig, and later he was renowned as a travelling virtuoso. By the age of 50 he stopped performing and devoted the rest of his life to teaching and experimental work.

2. Florio, Pietro Grassi (born before 1740; died London, 1795). Italian flautist and composer. He was in the Dresden court orchestra in 1756. He moved to London in about 1760.

3. Gedney, Caleb. Flute maker active in London in 1769, 1776, 1777 and 1778. His 1769 six-keyed flute is the earliest so far recorded and it belongs to the Collection of the Historical Society of Chicago, USA.

4. Potter. English family of musical instrument makers and musicians. The author refers to Richard Potter (1726-1806), London flute maker who started his business about 1745.

In the early nineteenth century the fashionable flute of the day was the eight-keyed flute, the model used by the legendary names like Drouet¹, Fürstenau², Nicholson³ and Tulou⁴. In 1820 Charles Nicholson introduced a large-hole model that produced a much bigger sound and influenced greatly Boehm on his breakthrough.

Since the days of Tromlitz and the beginning of the nineteenth century virtuosi, various efforts had been made to improve the eight-keyed flute, but nobody could actually conceive of a flute which was both perfectly in tune and playable. If the finger-holes were to be made in the positions dictated by the acoustics, the fingers would not be able to reach them.

The mathematical solution was found by Theobald Boehm according to the discovery of William Gordon. The name of Theobald Boehm (1794-1881) has been synonymous with the flute for over a century. The identification is a tribute to the man of inventive genius who created a revolutionary flute system and design to which flute players are still indebted. Yet this tribute has shrouded in a way the renown of Boehm, the nineteenth century German flute virtuoso and composer. It was Boehm's skill as a performer and composer that enabled him to play on his own inventions and convinced the music world of their worth.

William Gordon (who died in Lausanne in 1838), a Captain in a regiment of Charles X's Swiss Guard, was a keen amateur of the flute, being a pupil of both Drouet and Tulou. Gordon went to London in 1828 and asked flute makers Rudall and Rose⁵ to build a flute on his own design. The novelty was that each tone-hole was placed precisely where it should be, so that each note was in tune and the flute produced a perfect diatonic scale.

1. Drouet, Louis (born Amsterdam, 1792; died Bern, 1873). Famous French flautist. He played at the Paris Conservatoire at the age of seven and later became one of the most famous travelling virtuosi.

2. Fürstenau. German family of musicians. Anton Bernard Fürstenau (1792-1852) was the most famous flautist of the family. His frequent concert tours with his father Caspar Fürstenau (1772-1819) took him to Berlin, Frankfurt, Munich, Vienna and Prague, where he met Carl Maria von Weber in 1815. A prolific composer for the flute, he wrote variations and rondos on popular opera themes by Weber, Bellini, Meyerbeer and others.

3. Nicholson, Charles (1795-1837). The most famous English flautist of the nineteenth century. His very powerful tone was not universally admired, though it was regarded as a model in England. On the opening of the Royal Academy of Music in 1832 Nicholson was appointed professor of flute, and he also held principal positions of the Opera and the Philharmonic Society.

4. Tulou, Jean-Louis (1786-1865). French flautist. He was admitted at the Paris Conservatoire at the age of ten. In 1829 he was appointed professor at the Conservatoire, where he was bitterly opposed to the Boehm flute.

5. Rudall & Rose or Rudall, Carte. English firm of woodwind instrument makers and flute specialists, since the eighteenth century. The firm was absorbed by Boosey & Hawkes in 1955, but the name is still renowned. The name comes from George Rudall (1781-1871) who was in partnership with the Edinburgh flute maker J. M. Rose since 1820. In 1850 Rudall former pupil Richard Carte (1808-1891) joined the firm. Since 1871, when Rose's name dropped out, the firm has remained Rudall, Carte & Co.

Because the notes were no longer determined by the natural spread of fingers, keys were essential. A picture of Gordon's flute can be seen in Victor C  che's *Methode for flute players*, published in Paris in 1839 (its full title is *M  thode pour servir    l'enseignement de la Nouvelle Fl  te, invent  e par Gordon, modifi  e par Boehm et perfection  e par V. C  che et Buffet, jeune*). This flute left two finger-holes to be stopped by the fingers of the left hand, and three for the fingers of the right hand. The rest of the twelve holes, to be able to sound all the notes of the chromatic scale, depended on keys.

Gordon and Boehm met in London in about 1830 and after hearing Nicholson playing his larger-than-normal holes flute, Boehm rethought all his theories and began to investigate the laws of acoustics. Boehm's aim was to preserve the natural quality of the flute's tone, while improving the instrument's intonation. In 1832, he produced the conical Boehm flute, one of the greatest breakthroughs in the modern history of woodwind design. Besides enlarging the tone holes for greater dynamic power, Boehm's goal was to obtain full venting for the tones of the flute by having all the keys normally remaining open. His mechanism completely reversed the closed-key system that had evolved from the one-keyed flute. The problem of controlling thirteen open tone-holes with nine fingers was solved by an ingenious ring-key mechanism that enabled one finger to operate another key while closing its own hole. Boehm interconnected his rings in such a way that a more logical system of consecutive finger motions for the chromatic scale could be employed. This was the basis for his fervent insistence on using an open G#, but unfortunately, despite the wide acclaim won by his new flute, the habits ingrained over a fifty-year history of closed G# technique caused most flute players to be against it, and within six years, in 1838, Vincent Dorus, a flute player at the Paris Opera, had devised the closed G# key (the so-called "Dorus Key").

The 1832 ring key flute, adopted only slowly, never replaced the old-style flute, but several makers took up its manufacture and introduced some refinements in its mechanism. Whatever the improvements in fingering and in tone, there was no apparent improvement in intonation. The irregularities in the first two octaves were fairly large and the notes in the top octave became sharper as they ascended.

Boehm's crowning achievement was the introduction, in 1847, of a cylindrical flute with a tapered head joint, provided with a system of normally open keys covering very large tone holes.

The holes, he discovered, should have at least three-quarters of the diameter of the bore, making covered action (finger-plates) necessary. Hole one was an exception to the rule: for the sake of the upper D's it had to be smaller than the other holes, and placed rather high up on the flute. Boehm's hard work was very well rewarded when in 1850 at the Great Exhibition in Paris he won a prize for the flute, which was clearly superior to anything else available. Although some intonation faults remained, there is not much evidence that any appreciable improvements have been made since.

Boehm's flute maintains the familiar rising characteristic in the first register and break, and repeated rise in the second register. The sharpness of C# is still noticeable and there is a physical explanation for its occurrence - the size and position of the hole is a compromise. Because it is used as a vent or register hole for D2 and D#2, the C# hole has been moved up the tube from its normal position and made smaller in diameter to maintain the same frequency. It can be shown theoretically that a tube with such a hole will have its mode spacing slightly short of an octave. Therefore, if one wants C#3 to be in tune, C#2 must be made sharp. Flutes that are in use today do not seem to differ substantially in intonation from those made by Boehm, and in fact they exhibit very similar departures from the equal tempered scale.

Since Boehm invented the cylindrical flute in 1847, makers and players have continued to experiment, especially in England, to improve the flute. One of the interesting innovators of the 1840s was Abel Siccama. A Professor of modern languages, Siccama was also a great amateur enthusiast for the flute. He became fascinated with the concept of a keyless instrument and he designed a one-keyed flute, which unfortunately Ruddal and Rose decided not to manufacture. Later, in 1845, Siccama patented four flute designs, in one of which he incorporated the right-hand rings and Boehm's open G#. In 1846, he produced a model, which he called "The Chromatic Flute". Being dissatisfied with that model, after numerous experiments, he eventually produced the so-called "Siccama Flute", which he displayed at the Great Exhibition of 1851 (in the same year Boehm gained first prize for his cylindrical flute). The Siccama flute was in essence a conical flute with rather large holes and fitted with minimum of keys. That flute achieved some considerable success and was adopted among others by a most distinguished player of that time, Sidney Pratten, who gave up his eight-keyed flute in its favor.

Around 1852, Pratten began to experiment on improving the flute by combining the new flutes with the old system ones. He produced a number of flutes bearing the mark "Pratten's Perfected". In 1856, Pratten produced a flute, which combined the fingerings of the old eight-keyed flute with Boehm's cylindrical tube. He increased the size of the holes of the conical flute and added various keys, leaving the original eight-keyed flute as a seventeen-keyed instrument with holes practicably as large as those of Boehm. With the cylindrical flute his work was to bring it to the same fingerings as his seventeen-keyed conical flute. The flute was produced by the well-known London firm, Boosey & Co. The Pratten's Perfected flutes were quite popular in England, Australia and the USA, where they were used until the beginning of the twentieth century.

The next flute-maker who tried to improve Boehm's flute was Richard Carte (see p. 8). In 1850, he started working on a flute, which would combine the superior tone quality of Boehm's flute with the old closed-keyed flute, which was superior in facility of execution. Carte's work was rewarded with a prize medal at the Great Exhibition of 1851. That instrument appeared later that year, with some modifications, under the name of "1851 Patent Flute". It has already been mentioned that in 1850 Carte joined Ruddal and Rose as their third partner and continued to experiment on improving the flute. In 1866, he started on a new design which combined the most useful fingerings of the two instruments, his 1850 flute and Boehm's 1847 one. In 1867, he manufactured his new model, which was very successful and remained a favorite instrument of many English players until the middle of the twentieth century.

Before passing on to the next major British contribution, mention should be made about the Boehm's flute in France. When Godefroy-aîné¹ secured the manufacturing rights of the Boehm cylindrical flute, many French players found that the covered holes deprived them of certain "vented" fingerings and lighter sound they were used with the old system flutes. Godefroy had the idea of perforating the keys-plate and supplying them with annular pads. In this form, he and Lot² made cylindrical flutes of excellent workmanship, which remained the favourite instrument in France.

1. Godefroy-aîné, Claire (? – died before 1878). French maker of woodwind instruments, especially flutes and piccolos. Established in Paris by 1814, he won numerous prizes for his instruments.

2. Lot. French family of woodwind instruments makers. The author refers to Louis Lot (died Paris, 1890), who was established in Paris by 1855 and was famous for his flutes.

Another British attempt to improve the flute was done by Alexander Murray. In 1948, Murray, former principal flute of the London Symphony Orchestra and Professor of flute at the Michigan State University, became interested on Boehm's original open G# key flute. He began to reconsider also the possibility of having an open D# key, for it seemed as illogical to keep the right little finger down most of the time. Working in association with Albert Cooper and a mathematician colleague and flautist, Elmer Cole, Murray, after nine years of experiments, in 1958, produced a Boehm flute with open G# and D# keys, a full-sized C# hole and a separate D2 vent, both correctly placed. Thus, according to Murray, the compromised size and position of the small C# hole eventually was solved. As already described, Boehm had to adapt the C# hole for two functions: as a tone-hole for C#2, C#3 and C#4, and as a vent-hole for D2, D3, D4, D#2, G#3 and B flat3. In 1972, after meeting Mark Thomas (well-known American concert and recording flute player), then vice-president of the Armstrong Company, it was agreed to produce fifty Murray flutes and six Murray piccolos. Despite some evident advantages, especially added to the right-hand flexibility and apparent ease on producing C4, C#4, D4 and D#4, the Murray flute has not been widely accepted. This is probably because it is so difficult for a professional player to change radically everything that was learnt, and also to teach an instrument whose long tradition of methods and tutors have been based on standard fingerings.

A last mention should be made of the name of Albert Cooper, who in the second half of the twentieth century improved the scale of the flute by introducing the Cooper scale. Albert Cooper first started working at Rudall, Carte & Co. in 1938. When he left Rudall Carte in 1958 to establish himself as a flute repairer, he soon changed his mind and decided to become a flute maker. Cooper started making flutes on his own about 1960 in London, having as a model Boehm's equal-sized tone holes flute.

After a few years of experiments, Cooper devised a mathematically calculated scale, and found that in the octave length (the actual distance between C2 thumb hole and C1 hole on the foot joint) the most important thing is the position of the A hole. The interval between C2 and A1, and between C1 and A1 must be exact. The position for the rest of the scale is mathematically calculated to divide the interval C2 to A1 into three parts, so as to obtain the positions of B and A#, and the interval A1 to C1 into nine parts for G# to C# holes. These equal-sized tone holes, however, produce powerful low and middle registers but a problematic top register.

To get the best overall tuning, certain compromises should be made by moving certain holes from the positions arrived at by mathematical reasoning.

The basic principles of tuning are: if a hole is made larger it sharpens and if made smaller it flattens. If a hole is moved towards the embouchure it sharpens and towards the foot joint it flattens. The holes which have to be compromised are the F# hole, sharpened to allow the flattening effect of E and F holes, the low D1 hole, flattened to lower middle D2, which is slightly sharpened by the need to open the small C#2 hole, and C#1 hole on the foot joint, which is flattened to help the chromatic scale and deceive the ear.

Some flute makers have reduced the hole diameters, actually using three or four diameters within the octave length, to give the flute a better balance between all three octaves. When moving a hole Cooper also reduced its diameter without altering the pitch.

There are about one hundred flute manufacturers in the world today, probably due to the increasing popularity of the instrument. Japan produces about a dozen different makes, the most popular being Yamaha, Muramatsu, Sankyo, Miyazawa and Pearl. In Germany the supremacy is held by Johannes Hammig, with a three-year waiting list, and in the USA, Haynes, Powell and Brannen-Cooper have made the most famous flutes. Paradoxically, France, the country which for centuries held the supremacy of woodwind instruments inventions, does not produce an internationally accepted flute.

Intonation on the Flute

Modern flutes have a much better scale, but the intonation of some of the notes still remains a problem. The difficulty lies in the unevenness of the registers. As a general rule the low register is flat and it is difficult to play softly in tune, and the top one is sharp and it is very difficult to play loudly in tune. As will be noticed in the following chart the most-out-of-tune note on the flute is still C#2, which is very sharp. E1 is still flat and some of the very high notes like G3, G#3, B3, C4, C#4 and D4 are all very sharp, except for B flat3, which is quite flat.

Here is a chart of some out-of-tune notes, noticed on the flute and some basic methods to stabilise their pitch.

The measurements were done on the following flutes: Yamaha 211S, 311S, 411S, 511, 611; Miyazawa, Muramatsu, Sankyo, Haynes, Powell and Brannen-Cooper.

D1	-10	
D#1	-10	
E1	-10	
C2		has a sharp tendency on most flutes. (Right hand 23 will stabilise the pitch).
C#2	+10 to 20	(to lower the pitch add 123 of right hand).
E flat2	-	
E2	-	(open slightly the 2nd trill key)
D3	-	
E flat3	+10 to 20	
E3	+10 to 15	(in loud passages, one should take off the little finger of the right hand)
F3	+10	
F#3	+10	(by using the 2nd finger of the right hand, the pitch will drop a bit)
G3	+10 to 20	
G#3	+10 to 20	(by adding 23 of the right hand, the pitch will stabilise)
B flat3	- 10	(when playing softly, one should use the 2nd trill key, instead of the first trill key)
B3	+	
C4	+ 20	(on open-hole flutes, one can press down the F key on its rim, and the pitch will drop quite well)
C#4	+20	
D4	+20	

As one can see, with the exception of some of the notes, the flute's pitch tendency is to be flat at the bottom and sharp at the top. The best advice for improving the pitch tendencies are to play firstly each note with a tuner, and than make a chart of problem notes in different dynamics. The main problem of adjusting the pitch is to maintain the most beautiful sound, and this technique requires a great deal of work, patience and dedication. One has to know exactly the pitch tendencies of one's own instrument, to be able to adjust accordingly when playing in the three systems of tuning. When playing in an ensemble, unfortunately the intonation takes priority over the quality of the sound, and if nothing helps, one should refer to alternate fingerings, trying to maintain a beautiful sound.

Poor intonation of the flute can be traced to the following sources, described here in order of their importance:

1. Incorrect embouchure.
2. Using the wrong register when tuning.
3. Failure to keep the flute warm, both before tuning and throughout a performance.

1. It should be remembered that good intonation is very closely allied to good tone production. The embouchure should be very flexible in order to play in tune at different dynamics with a constantly beautiful tone. There are two main ways of altering the pitch of a note: firstly by varying the tightness of the embouchure, and secondly by raising and lowering the head (one must rule out the rolling of the flute in or out, as this technique produces a very poor sound quality). Without doubt the first method is preferred as the second slightly changes the quality of the sound. The speed of the air stream is also very important as a faster speed, in *forte*, will raise the pitch considerably: a fast speed of the stream of the air is necessary when playing *pp*, a technique also helped by a greater support of the abdominal muscles. However, there are two occasions when one should use the second method. Firstly, in making a strong attack on *forte* it is necessary to drop the head, helping the pitch not to go too sharp, and at the end of a phrase ending in *diminuendo*, when one should lift the head, thus preventing the note from going flat (a stronger abdominal support will also help).

As regards embouchure, one should remember that the jaw controls the direction of the air. As stated above, to avoid playing sharp at the top on loud dynamics, one should direct the stream of air down, more directly into the flute, at the same time relaxing the jaw. By playing slightly softer the pitch will also be stabilised. To avoid playing flat in the low register, one has to blow higher into the flute, at the same time giving a much stronger support from the abdominal muscles. In the author's experience, the most difficult thing is playing softly in the low register with a beautiful tone, and in tune (just a reminder of the flatness of the first five or six notes on the flute).

When playing orchestral works which start with a flute solo, marked *piano* or *pianissimo* (like for example Debussy's *Afternoon of a Faun*, Ravel's *Bolero*, or Fauré's *Pavane*), the best advice is to tune higher, by pushing the head-joint in (one must not forget to pull it out to the original tuning position after the completion of the solo).

2. Another source of bad intonation is the use of the wrong register when tuning. This faulty technique is noticed quite frequently when playing with piano. A common mistake is to tune on the first A and then start playing on the upper second register *forte*. As a result, the second octave will be very sharp, and the top one extremely sharp. Mention should be made to adhere to the equal temperament, and to remember that at the end of the piece, when usually the flute plays on the top register, the pitch will rise dramatically and a perfect tuning is needed. A better sense of intonation will be achieved by tuning on A in the second octave. Care should be taken not to play too flat at the bottom or too sharp at the top. The only time that one should tune on the first A, is when the flute plays softly, and the compass of the piece does not go too high in the upper register.

3. The flute, as well as all other musical instruments made of thin metal, becomes warm as air is blown into it and cools off quickly when it is not played. Thus, if a flute is tuned when cold, it will play very sharp when warmed up. The main problem is when not playing for a while (as sometimes in symphony or opera orchestras, after many bars rest), and then playing in an exposed passage, then the flute will sound flat. The solution is quite simple: the flute must be kept warm by blowing warm air through it, fingering low C or B (all keys must be closed). As stated above, the quality of the sound should be as beautiful as possible, and this simple technique will greatly improve the overall tuning. It should be remembered that the blowing should be done very discreetly and silently before playing each new entrance, paying attention not to disturb other players or the performance in any way.

The Piccolo

The history of the piccolo, generally speaking, parallels that of the D flute. Its immediate progenitor was the military fife of the Middle Ages (c. 500-1430 A.D.) The fife was a small cylindrical flute with six finger holes. It was used mainly by the Swiss military in the sixteenth century and soon spread throughout Europe. The first illustration of a fife appeared in Marin Mersenne's *Harmonie Universelle* of 1637 (see Flute, p. 4). Mention should be made of the fact that instruments had different names in Handel's time compared to the modern ones. For example, *Flauto piccolo* referred to a descant recorder and the *flageolet* was a small, narrow recorder with six holes. The fife of the seventeenth and eighteenth century retained the same characteristics of the fife of the sixteenth century, as a small transverse flute in one piece. The piccolo became a two-piece instrument, with the introduction of the D# key during the Baroque era. Like the flute it gradually acquired more keys, though it never adopted the foot-joint as the flute did. It is essentially a structural product of the eighteenth century, but did not achieve great orchestral importance until the nineteenth century.

The nineteenth century piccolo did not gain acceptance immediately, so the older instruments with four or five keys had continued to be used. During that time over forty different fingering systems of piccolos were made out of cocuswood, boxwood, brass or silver. Johann Tromlitz (see Flute, p. 7) was credited with creating the multi-keyed piccolo in 1791, but there is no reference in Tromlitz's book to support it. Another reference about a multi-keyed piccolo appeared in 1824 in an article in the *Berliner Allgemeine Musikalische Zeitung*, where a piccolo with six keys, very similar to the six-keyed flute, was mentioned.

Theobald Boehm (see Flute, p. 8) should be also mentioned in the development of the piccolo as he applied his flute system of fingering to the piccolo as well. Several French flute makers produced Boehm-system piccolos in 1830, but unfortunately no specimen from that period survived. However, there is a beautifully made Boem piccolo by Godefroy-aîné in the Paris Conservatoire Museum. It is made out of cocuswood and it has two head joints. The left-hand A and all three right-hand keys for F, E and D are perforated, a characteristic feature of the French system flutes. In Germany, Boehm employed Thomas Mollenhauer¹ between 1862 and 1864.

1. Mollenbauer. German family of woodwind instrument makers, active from the early nineteenth century. Thomas Mollenhauer (1840-1914) was famous for his bassoons and clarinets.

During that time, Mollenhauer tried to improve the piccolo by retaining the cylindrical bore of the instrument and experimenting with different bore sizes, and head joints. These experiments were quite unsatisfactory as the high register was not responding well and the tone was quite sharp. Mollenhauer then tried to use a conical bore with a cylindrical head joint, and apparently that combination was more successful. Unfortunately the archives of his firm were destroyed during the World War Two and details of his experiments were lost.

At the end of the nineteenth century some players, especially in England, used piccolos that had cylindrical head-joints and conical bodies that narrowed toward the bottom end. The conical bore produces a more full-bodied, pleasing tone, better balanced through the compass. Modern piccolos may have either a cylindrical or conical bore. The cylindrical bore, in contrast, tends to give the instrument a thin, shrill tone quality and makes the low register often faulty in intonation. But the cylindrical bore makes the high register much easier to play.

Except the normal piccolo in C, piccolos were also made in D, D flat E flat and F. Although the piccolo in C has been standardised as the most useful orchestral instrument, the D flat piccolo has also been used, especially in military bands in England and in the USA. In 1914, Nicholas Alberty of Chicago invented a transposable piccolo in C and D flat. Externally, the piccolo appears little different than an ordinary Boehm-system instrument, but inside the head-joint there is a tube of thin metal, which slides accurately inside the body. In this tube, which is slightly longer than the body, are cut all the holes required to play a normal piccolo, plus an extra one. When the head and the tube are pulled out the instrument behaves exactly as a normal C piccolo, but when the head is pushed in, the hole mechanism moves up one hole and thus raising the pitch by one semitone.

On the contemporary scene Alexander Murray (see *Flute*, p. 12) applied his flute reforms to the piccolo as well, and in 1972 the Armstrong Company, of America, produced five Murray piccolos, each made in two joints. In 1992, John Fonville, a flute Professor at the University of California at San Diego, approached flute makers with the idea of an open-hole piccolo with two additional quarter-tone keys. These open-hole piccolos work well in microtonal music, because they can produce perfect quarter-tones. There are two extra keys for producing the quarter-tones, the F# and the B flat keys. The idea was to encourage composers to explore the potential of the new open-hole quarter-tone piccolos in the modern music.

Today piccolos can be entirely of wood (best is granadilla wood), or of metal (nickel-silver or silver). Some of the manufacturers use wood for the body and silver for the head-joint. The most popular manufacturers of piccolos are those of Hammig in Germany, Yamaha in Japan, and Haynes, Powell and Brannen Brothers in the USA.

Intonation on the Piccolo

It must be said that the piccolo is one of the most difficult woodwind instruments to play in tune. Because of the "forceful" air stream required to make a full-bodied sound, it tends to go sharp. Being a supersensitive instrument, its intonation could be affected by the slightest alteration of the pressure of the air stream or lip position. The acoustical explanation is that the higher the register, the smaller the difference in frequencies between notes.

The low register of the piccolo is quite in tune; only the E flat is about 5 cents flat. The C#1 is in tune, but from the A#2 the notes have a flattening effect of 10 to 20 cents, C#2 being by far the flattest note on the piccolo. The only note that is sharp is D2. On most piccolos D3 is quite flat, 10 to 20 cents. The top register is quite in tune with the exception of A#3, which is very flat. There is no question that in extreme dynamics one has to use alternate fingerings.

The measurements were done on the following piccolos: Yamaha 32, 62 and 82; Haynes, King, Philip Hamming and Richard Hamming.

Here are some of the most important fingerings for adjusting the pitch of some of the out-of-tune notes. For the fingering one should use the following system, from left to right: T for left hand thumb and 1234 representing the fingers, and the right hand just 1234.

Thus, when all fingers are down on all keys one reads: T1234/1234

(LH) (RH)

Thumb B flat = T flat

1st. trill key = tr 1

2nd. trill key = tr 2

The following fingerings are for the notes which are usually flat:

A#/B flat 2	T1 3/ 1234 slightly sharp, but very good for soft sustained playing
B2	T1 3/ 12 4 slightly sharp
C2	123/ 1 3 or 1 34
C#/D flat 2	23/ 2 4
D3	T 234/1 4
D#/E flat	for very soft playing, one should open the first finger of the left hand.
E3	normal fingering with tr 2
F3	T1 4/1 tr 2 4
F#/G flat 3	T1 3/ 23
G#/A flat 3	234/ 234
A#/B flat 3	T / tr 2

It is extremely important to learn these fingerings for playing in tune on the equal tempered system. As we will see in the next chapters some of the flat notes should be "corrected" even higher in just intonation, or when harmonically they represent leading notes.

A piccolo player should know all out-of-tune notes and tendencies of the E flat clarinet, with whom he/she plays most of the unisons and generally all wind instruments' tendencies. The piccolo, playing in the high register most of the time, has no place to hide.

The Alto Flute

The alto flute has been wrongly called the bass flute for years. Actually a bass flute if pitched in C and sounds one octave lower than the normal flute in C. The ancestor of the alto flute dates from the beginning of the sixteenth century. There is a picture of a flute quartet from c. 1500 by Urs Graf (1485-1527) showing a bass flute in one piece with six finger holes. Later in the seventeenth century the flute was often made in two joints. The distances between the finger-holes on these large flutes, made it necessary to employ some sort of keys in order to enable the fingers to control the note-holes. These large flutes were called alto flute, bass flute or bass flute in G, because they were pitched a fourth lower than normal C (i.e. when C is played it sounds G).

There is a picture of an alto flute in the *Encyclopaedia* written by Diderot and d'Alembert, published in 1751. It shows a large wooden flute with a curved head-joint that brings the embouchure closer to the hands. This flute sounded a perfect fifth lower than the C flute and its tone and pitch were probably inconsistent because the curved wooden tube was cut by hand.

During the eighteenth and nineteenth centuries, numerous attempts were made to improve these flutes, but only in the second-half of the nineteenth century did a breakthrough take place. Around 1875, Theobald Boehm, the inventor of the modern system of flute that bears his name, brought out a silver alto flute in G. His measurements were exactly as for the C flute and the model he invented is still used today.

The most famous alto flute solos were written by Ravel in *Daphnis and Chloë*, Stravinsky in the *Rite of Spring* and Holst in *Saturn* from *The Planets*.

The main alto flute manufacturers of today are Hammig in Germany, Buffet in France and England, Miyazawa, Yamaha and Muramatsu in Japan, and Haynes, Powell, Armstrong, Jupiter and Brannen-Cooper in the USA.

Intonation on the Alto Flute

The range of the alto is exactly the same as the C flute (three octaves), but the practical one is two and a half octaves. Overtones and inconsistent pitch create problems in the upper register from D3 to C4. As a general rule the upper register of the alto flute is sharp varying from +10 to +25 cents, only the C# 3 is very flat. The middle register is quite in tune; only the break from A#2 to D2 is very sharp (+15 to +20 cents). The low register is also quite in tune, with the exception of C1 which is very sharp and D#1 which is very flat. The notes referred to are the fingered notes, not the concert notes, which will be a fourth lower.

The measurements were done on models by Gemeinhardt, Buffet and Haynes.

Here is a chart with some out-of-tune notes on the alto flute:

C1	+10 to 20
D1	-
D#1	-10 to 20
A#1	+10 to 15
B	+10 to 15
C2	+20
C#2	+20
D2	+15 to 20
E2	-
F2	-
F#3	-
C#3	-10 to 20
D3	-
D#3	+10
E3	+20
F3	+10 to 15
F#3	+10
G3	+10
G#3	+20
A3	+
B3	+
C4	+30

As a general rule, most of the alternate fingerings for the normal flute work for the alto flute as well. Here are some suggested fingerings to lower some of the too sharp notes of the third register:

E flat3 finger G# and add Tr 2 (second trill key).
E3 normal fingering / little finger of the right hand off.
F#3 normal fingering, but use the middle F# key (2 instead of 3).
G3 finger C2 and add 23of RH (right hand).
G#3 as on flute and piccolo, add 2 and 3 of RH.
A3 T 2/12 4

The E, F and F# in the middle register, which are usually flat, can be improved by adding the second trill key.

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The Oboe

Reed instruments developed much later than the flute. A proper reed instrument, a vibrating reed coupled with a tube, is apparently a product of ancient people of the Euro-Asian continent. The earliest oboes discovered were excavated by Sir Leonard Woolley¹ at Ur, and they are probably from 2800 BC. The history brings us to the *Brahmin* epoch in India, from the twelfth to the seventh centuries BC, when they used an instrument called *Otou*. It was a conical instrument with no finger holes, the reed was shaped in a triangle, and like all traditional instruments it has been used for many centuries and is still used today in ceremonial dances. The player holds the instrument in the left hand and can sustain the sound indefinitely by using circular breathing (inhaling through the nose while blowing).

Oboes were developed and used for ceremonial purposes in various forms and in different countries. Burmese and Mongolian instruments are like long trumpets with bells, played with a very stiff reed. Chinese instruments are similar to Indian types. There is a written record of a Chinese oboe called *Koan*; a single reed gave it the sonority of a small child's cry. The large ones had eight holes: seven on the front and one for the right-hand thumb. An interesting feature of these instruments is that they were held, contrary to present day practice, with the right hand above the left one. Today it is still possible to find such primitive instruments like that in Mexico whilst in Egypt the oboe was introduced during the New Kingdom, in about the fifteenth century BC. The Greeks and Romans developed dozens of wind instruments, which they classified into two major categories: the Greek *auloi* (the Roman equivalent was *tibiae*), the ancestral of the oboe, and *syrinx* (the Roman equivalent was *fistulae*), the ancestral of the flute.

A very interesting description of the *auloi*'s double reed, called "zengos", was done by Aristotle: "the zenge of the *auloi* must be compact, smooth and uniform, in order that the column of air which passes through them may also be smooth, uniform and uninterrupted. This is why the zenge moistened with saliva have a more mellow tone, while, when dry, they have a coarse tone, for the air which traverses a moist, smooth body is soft and uniform". What better advice could a contemporary oboist have?²

1. Woolley, Leonard (1880-1960). British archaeologist. He excavated in Syria, Egypt, and Ur in Iraq. His most popular book *Ur of the Chaldees*, was published in 1929.

2. Goossens, L and Roxburgh, E., *Oboe* (London, 1980), pp. 7-8

Perhaps one of the finest representations of the auloi-player is in the fresco of *The Tomb of The Leopards*, Tarquinia, (480-470 BC). The Etruscans were Greek in culture, and the pipes shown are very characteristic, the most used being the double pipe ones. The only specimens from the Classical epoch of Plato and Aristotle are the wooden pipes, the Elgin auloi, which are in the British Museum. The two pipes are beautifully made, with undercut holes and polished cylindrical bore. On each pipe one could play an entire octave with one hand, because the holes give a pentatonic scale. Trials of replica of the Elgin pipes, using reeds of the Chinese *kuau-tzu* type, gave A, C, D, F (or E), G and A.

Although the pipes usually had four holes, the lowest was left open, the little finger being occupied with holding up the instrument from underneath (it should be remembered that the player used only one hand). Later instruments (e.g. pipes from Pompeii of Caesar's time) have revolving metal rings, evidently for pre-setting the pipes in the desired key. Other late instruments appear even to have had sliding keywork, which remind us of our woodwind instruments' keys. To judge from the surviving pieces of Greek auloi, these one-octave instruments would have sufficed for much of the music. However, there is the possibility that the actual compass was larger: overblowing is possible on the narrow Egyptian pipes and with only four holes one can make a continuous scale in the treble register, by playing on the third and fifth harmonics. On the wider-bored aulos this was more difficult.

There was no significant development of the oboe from this time until the Middle Ages. The oboe family survived mainly through the bands of travelling musicians, minstrels, troubadours and Town Guilds. At the time of the Arab occupation of Persia in the seventh century, a union between the two cultures produced the Arabian oboe, which was of Persian origins. That was the *zamr*, or *surna*, derived from the Persian *shawm*. The characteristics of this instrument are very close to the early oboe. The instrument was made of a single piece of cherry wood; the reed was tied to a metal staple and the bore continued straight from the larger lower end. The neck had a movable metal disc against which the player pressed his lips. This indicates that the reed was completely inside the mouth. The compass of this instrument varied between two and three octaves and the Turks used it mainly for military bands.

The windbag variant of the Greek aulos is a constant partner to the mouth-blown instrument throughout the history. It has been described as a "folk-shawm", and its importance is essential to the eventual union of the two kinds in the modern oboe.

Some examples of the windbag oboe were used for folk-dancing in the Middle Ages and Renaissance. Varieties of these instruments include pommers, bombardours, chalumeaux and musettes. They had a small range not exceeding one and a half octaves. At the time when each category of instruments was made in several sizes to form a consort, the oboe family in the form of shawms, were strictly for the military and town bands. The oldest illustration of a shawm of the early fourteenth century is in the British Museum, while the earliest written account of it is given by Tinctorius¹ in about 1486. It was over a century later, in 1618, that a complete set of different sizes, from the higher treble to the double bass, was described by Praetorius². They were:

Klein Discant Schalmey
Discant Schalmey
Alt Pommer
Tenor Pommer
Basset Pommer
Bass Pommer
Gross Bass Pommer

The body of the shawm was in one piece; the outside shape was cylindrical or slightly tapered in outline, and expanded at the end into a trumpet-like bell. Internally the tube was conical for about four-fifths of its length, below which it flared in a fairly smooth curve. Six finger-holes gave a primary scale of an octave, and a seventh hole set below these carried the compass one tone downwards. In the European shawms there was no thumb-hole, as was usually found in the Oriental ones. Like certain instruments even in the present day, the shawm was at its best in a limited number of keys and they were to some extent dictated by the compromise spacing adopted for the finger-holes.

On the smaller shawms the seventh hole, stopped by the little finger, was regularly duplicated and placed to the side, out of line with the other six. From the tenor pommer downwards the hole nearest to the bell was too far for the little finger to reach, so a key was used. The fishtail shape of the touch-piece was designed to accommodate the little finger of either hand, according to the player's habit. In order to protect the key from damage it was covered by a perforated wooden barrel called a fontanelle, which left only the touch-piece visible.

1. Tinctorius, Johannes (c. 1435-1511). Composer and theorist, he wrote twelve treatises which together constitute a major source for the music of early Renaissance.

2. Praetorius, Michael (1571-1621). German composer and theorist. In his major work, *Syntagma musicum*, he provides an invaluable survey of the musical practice of his time.

The key gave an extra note below the basic octave of intervals derived from the six finger-holes. An extra hole at the bell of the instrument was plugged with wax when tuning demanded it.

The blowing system consisted of three separate parts: the staple, the pirouette and the reed. The staple was a tapered metal tube, which was inserted in the top of the main bore. Upon that was impaled the pirouette, a turned wooden piece bored down the middle and shaped like an inverted bell. A small hollow was cut in the face of the pirouette to fit the reed. This arrangement was evidently designed to guide and support the lips and was an improvement on the ancient Eastern prototype, where the pirouette was a flat metal disc, against which a player pressed his lips, taking the entire reed into the mouth, and practically having no control over the behaviour of the reed. It was on account of this facility that the compass of the shawm, by overblowing, could be extended above the single octave of notes normally available on instruments which have no thumb-hole. The technique of the pirouette can be seen today among the Sardana musicians of northern Catalonia, Spain.

In the middle of the seventeenth century fresh ideas were experimented with in Europe. In Italy the first operas originated, and in France instrumental music was being organised with imagination. During the reign of Louis XIV (1642-1715), musical organisation reached its highest state. The musicians employed at his court could have been part of the Chapel, the Chamber Music and above all the Grande Ecurie. The Grande Ecurie represented the largest and the most prestigious ensemble and was administered by the Master of the Great Stables of the King. Among the musicians of the Grande Ecurie, two names are to be mentioned for their revolutionary contribution to the development of the new oboe: Jean Hotteterre¹ and Michelle Philidor².

After numerous experiments involving the shawm and the mussette (a French small bagpipe), around 1650-1660, a new *hautbois* was born. It was a three-joints oboe, which may well have been tried in Lully's (1632-1687) ballets, but the first recorded use of the oboe in orchestration was in Cambert's (1628-1677) opera *Pomone* in 1671. The instrument gained immediate popularity in many countries.

1. Hotteterre, Jean (?-c. 1678). One of the most outstanding makers of the famous Hotteterre family, which includes about thirteen good musicians and instrument makers.

2. Philidor, Michel (?-c. 1678). A member of a celebrated family of musicians, he is recorded as playing in the Grande Ecurie in 1651, and considered the co-inventor of the true oboe.

By 1695 the first oboe tutor was published in England, in *The Sprightly Companion*. Henry Purcell (1659-1695) composed for it as early as 1681 and used it until his death. By 1715 English town bands abandoned the waits (name given to the older instruments from the shawm family) in favour of the new *hautboy*. With this the shawm family ceased to exist.

The two and three-keyed baroque oboe was used throughout the eighteenth century with very little change. The three-keyed oboe with a fish-tail key for playing E flat with either left or right hand was very popular in the first half of the century, and, after 1750, the two-keyed oboe models were the standard instruments of the time, requiring a uniform approach to the hand position, left hand above the right one.

Around 1700 James Talbot¹ provides an invaluable description of the baroque oboe: it has six finger holes (three for each hand), the third and fourth featuring double holes to produce the four chromatic notes F, F#, G, G#, a pair of small closed keys below D, and a single key below that for C (called the great key). It also had a long bell with two tuning holes. The reed had no pirouette, being left free for the player to control it with his lips. It had a compass of two octaves from C1 to C3. Simple fork-fingering could provide some of the semitones, but others could not be obtained without some adjustments to the actual holes. The result was a certain degree of compromise, with ambiguous tuning, for which the player was expected to compensate with both his lips and fingers. In the majority of examples, the upper three holes were much smaller than those of the lower set, and often they were pierced obliquely. It has been proved that this oblique piercing of some holes could affect the tuning only on long-tubed instruments with thick walls (e.g. the bassoon), but on a comparatively short oboe, the advantage gained had more effect on tone-colour than on tuning. The note which was definitely flat on most of the oboes was the F#1. This is because the hole had to be tuned in the first place to give a good forked F natural for which there was no alternative. Several alternatives for F# are found in different instruction books, and this seems to be one of the most controversial notes. Actually the number of alternatives, since they had their own shades of intonation, makes it clear that a good player on the two-keyed oboe had a very considerable control over intonation, more than the average modern oboist.

The transition to the mechanised oboe was not too smooth and the two-keyed instrument of Mozart's orchestra was still used by some players as late as 1820.

1. Talbot, James (1665-1708). English writer on music. His importance to music history derives from his manuscript (c. 1695), which provides detailed information on instruments.

During the first quarter of the nineteenth century, six further keys were added, probably in the following order:

1. A closed G# key for the left little finger, supplementing but not replacing the doubled hole, which survived at least until 1865.
2. A vent-key for the right little finger, which covered a hole almost mid-way between hole four and five. This greatly improved the intonation of the F# with the normal fingering.
3. The low C# operated by the right little finger.
4. A closed F natural.
5. A closed B flat on the upper joint operated either by the left thumb or the right forefinger, and later on by both as alternatives.
6. A closed upper C natural.

Probably the most advanced instruments that still exist from this period are those made according to the ideas of Josef Sellner (1787-1843), a famous performer who played under Weber and who was later a member of the Court orchestra in Vienna. He added extra levers to the B flat, F natural and D# keys and thus inventing the so-called Sellner's thirteen-keyed oboe, for which he also published a tutor in 1825, later translated into French and Italian. Sellner may be regarded as the father of the modern German oboe.

The difference between typical instruments by makers like Thomas Lot or Charles Delusse of Paris (they were both making oboes in Paris from 1740 until 1789) on the one hand, and Karl Grenser (1720-1885) and Jacob Grundmann (1727-1800) of Dresden on the other hand, shows that the French were cultivating a refined tone, while the Germans favoured robustness. By 1820, however, two entirely different ideas of oboe tone led to the manufacturing of two types of instruments. In the French oboe, the upper bore was beginning to get narrower. By that time the four-keyed oboe was quite popular. When Sallantin¹ was appointed professor of oboe at the Paris Conservatoire, he added the low B natural and F# keys. The conservatism of Sallantin and Vogt² (Sallantin's pupil and successor at the Conservatoire) was by no means unchallenged in Paris, and players and makers tried to improve the four-keyed oboe.

1. Sallantin, Antoine (1754-1816). The first professor of oboe at the Paris Conservatoire; while playing first oboe at the Opéra he is known to have used an oboe with only four keys.

2. Vogt, Auguste-Gustave (1781-1870). French oboe player. A devotee of the four-keyed oboe, Vogt played first oboe in numerous French orchestras, like Opéra and Société des Concerts. He was also professor of oboe at the Paris Conservatoire from 1802 until 1825.

In 1835 Henri Brod¹ in association with Guillaume Triébert² constructed an eight-keyed oboe. Brod himself set up as a maker and made some notable improvements to several members of the oboe family. He used metal pillar mounts for all his keys and adopted shallow metal cups for the key-pads. Brod published his famous *Méthode* in two volumes, and in the second volume he claimed to have devised the so called half-hole plate for the left forefinger, as a result of the trouble some of his pupils had experienced in closing the upper C# hole. Half closing, or rather half opening this hole for the production of certain upper harmonics, became an essential point of technique after the compass was extended to C3, and very shortly it was found to have advantages in the lower octave as well. This mechanism is to be found on almost every oboe today.

The name which is synonymous with the French oboe is Triébert. Guillaume Triébert opened the business in 1810, which lasted until 1876. The family created six different models and a complete transformation of the oboe took place under their supervision. Between 1840 and 1880 the instrument was completely reformed, particular attention being given to the bore and the placing of the tone-holes. A reed narrower and lighter than formerly used, was found to favour the French ideal of tone. At the same time mechanical facilities were continuously improved and Boehm's ideas were put to numerous uses: pillars were screwed directly into the wall of the tube, making the upper joint completely smooth.

A typical French oboe of 1840 shows the following arrangements: C, C# and D# keys all on separate levers operated by the right-hand little finger; a low B natural and duplicate D# with long levers for the left-hand little finger; a cross F natural on the lower joint; the F# lever was replaced by a "spectacle" key; a cross G# for the left-hand little finger supplements the double hole of the third finger, right hand; a half hole plate for C#, and the octave key, operated by the left thumb. The first development of that oboe (which was called by Triébert himself "Système" 3), showed only two changes, the use of axles instead of levers for the right little finger and the adding of a second octave key (used from A2 upwards). An instrument of this model is known to have been used as late as 1865.

1. Brod, Henry (1799-1839). A pupil of Vogt at the Paris Conservatoire with whom he later shared the oboe desk at the Opéra, Brod became dissatisfied with the four-keyed oboe and made valuable improvements to it.

2. Triébert. French family of woodwind instrument makers. Guillaume Triébert (1770-1848), started as a cabinet maker and later became one of the most accomplished oboe and bassoon makers.

Système 4 appeared about the time of Guillaume Triébert's death and was adopted by Barret¹, another pupil of Vogt, who went to London and became solo oboe at Covent Garden in 1829. Barret's invention consisted of the addition of a low B flat key and made it the basis of his tutor, published in 1850. This model had a ring for the second left hand finger obtaining a forked C, a key for C-D trill and touch-levers for the left hand B and D#. Many oboe-players today still use a thumb-plate attached to a Conservatoire system oboe. It has certain advantages of alternative fingerings both for intonation and technical facility. This system does away with the half-hole characteristics of G, making the upper and lower octaves using virtually the same combination of fingers for relative notes.

In spite of the enormous advantages which had been conferred on players by the above mentioned instruments, there still remained the difficulty of moving the right hand from the normal fingerings of B flat and C natural in the middle and upper registers to the holes of the lower joint. This difficulty was brilliantly overcome on the oboe *Système 5*. The holes for the B flat and C natural were transferred from the side to the front of the tube and each was provided with a cross-key. Attached to the C natural key is a ring surrounding the B natural hole and to the B flat key a touch-piece for the right forefinger. These keys are both slightly sprung to stand open and their tails engage with one end of a spring clamped at the other end to a plate under the left thumb. The effect is that when the oboe is held in a normal position, the pressure of the thumb holds the keys closed but a pressure of the right forefinger allows one or both keys to open. Thus the notes B flat and C natural can be played either by the normal fingering or by simple release of the left thumb, especially in tricky passages. The above mechanism is called today the "Barret action" even though some elements of that arrangement are described in a patent granted to Triébert in 1849. A later addition to the *Système 5* was a low B natural key for the left little finger.

Before describing Triébert's last models, it would be important to mention an oboe made in the 1860s, known as the full Barret system oboe which had for some time a considerable vogue, especially in England.

1. Barret, Apollon Marie-Rose (1804-1879). A pupil of Vogt at the Paris Conservatoire, he played first oboe at the Odéon Théâtre and Opéra-Comique. In 1829, Barret moved to London and played first oboe at Covent Garden. He also taught at the Royal Academy.

The main feature of Barret's oboe, as he himself outlined in the introduction of the second edition of his *Method (A Complete Method for the Oboe)* was published firstly in 1850 in London and an enlarged second edition in 1862), are related to the two octave keys, to have more perfect shakes on each note and to do away with the half-hole.

The two octave keys were arranged to open when released by a movement of the left thumb, the selection being governed by a ring for the third left finger. Passing from G# to A in the second register was done automatically and a duplicate touch-piece took the position of the former second speaker. The most important feature of this oboe was probably the arrangement used to control the upper B flat and C natural keys. As in Triébert oboe of 1849, these keys sprung open and were closed by a thumb-plate, but the counter pressure was not applied by a touch-piece at a side, but by any right hand finger; the right hand rings were linked with the upper joint mechanism by a light lever. If the B flat was not required, the ring for the left third finger (attached to the automatic octave) was provided with a lug, which held the key down until the A hole was opened. The position at the side of the upper joint formerly occupied by the C natural key was taken up by a duplicate touch-piece for the G#, and a ring for the right forefinger was arranged to overlap the cup of G# key. Thus one could close the key without the need to release the left little finger, giving an easy trill on F#-G#. Today this action is known as "articulated G#", and is used on both oboe and clarinet. Various other trills were obtained by the addition of duplicate touches.

Barret's reference to "do away with a half-hole" is quite controversial. The evidence of surviving instruments suggests that he objected to the sliding of the left forefinger which is necessary to open partially the upper C# hole. The half-hole for C# is however essential in all modern fingering systems and in a drawing in the second edition of his *Method*, one could see a pierced plate covering the hole and linked to a small touch-piece for the left thumb, as to the ring which governed the automatic octaves. By this device the half-hole also operated automatically for all normal fingerings, without any sliding or rolling of the left forefinger.

Triébert's sixth and last system acknowledged a common dissatisfaction among the players with the thumb-plate (the use of the left thumb to close the B flat and C natural keys). A similar device to Barret's was adopted, with the difference that the right forefinger alone was used to operate these keys, the thumb-plate being abolished.

A secondary advantage of this mechanism is that the closing of the G natural hole, which occurs every time it is used, has the effect of steadying the B flat-C natural. In addition, the articulated G# with alternative touches was incorporated, the low B flat key and an improved form of octave key to smooth the change from G to A. With all these features the basis of the Conservatoire system was laid.

After Triébert's death his friend and colleague F. Lorée¹ took over the firm and continued to experiment, shortly producing *Système 6*, in which any of the first three fingers of the right hand could operate the B flat-C natural mechanism. The eminent player Georges Gillet² had considerable influence on Lorée's oboe and in 1882 he adopted the *Système 6* for the Paris Conservatoire. From that date this type of French oboe without thumb-plate, has been universally termed the "Conservatoire" model, although a distinction is sometimes made between *Système 6* and A 6, by calling the later the "Gillet *Système*" (that system which incorporated cover plates on the rings was produced by Lorée's son in 1906).

At the end of the Triébert period a few defects still remained in the scale of the oboe, most of which have since been remedied. These concern trills in different registers and the production of F natural. This note, produced by the cross key for the third finger of the right hand, has been an excellent one. The same note produced by the forked fingering is often flat because of a slight re-positioning of hole no. 5, which over the years has been connected to the tuning of certain other notes. Even when in tune, the forked F natural is often dull and stuffy in quality. A solution was to open the E flat key immediately below it, but this overcorrects the pitch and it occupies the little finger, which may be required for other notes. This problem was also dealt with by adding the cross F natural with a second lever, controlled by the left little finger – the so-called "long F".

The subject of mechanisation cannot be left without reference to Boehm. His principle was that in making wind instruments with side-holes, the number, size and position of the holes should be established first, the means of controlling them being left to second place.

1. Lorée. French firm of oboe makers. Francois Lorée (?- 1902) worked for Triébert from 1867, and in 1881 opened his own firm. His son, A Lucien Lorée (1867-1942) produced in 1906 the "Gillet model", after Georges Gillet who influenced the Lorée's work.

2. Gillet, Georges (1854-1934). He obtained first prize at Paris Conservatoire at the age of fifteen, and played principal oboe at the Théâtre-Italien, Société des Concerts, Opéra-Comique and Opéra. From 1881 until 1929 he was professor of oboe at the Paris Conservatoire.

Boehm also found that ideally most of the holes should be bigger than could be easily covered by the fingers. Having designed the tube of the flute, Boehm's next problem was to find an appropriate mechanism and in this he proved his genius. By attaching the cups to longitudinal axles, which also carried rings surrounding four of the finger-holes, he enabled the available digits to operate them all as required. The benefits of the ring mechanism were quickly recognised by instrument makers and soon a number of applications were found. One of them was to render automatic the F# vent-key on oboes and clarinets.

Boehm's mechanism and his principles soon found a rapid appreciation and before 1840 several makers were trying to apply them to other instruments. Boehm himself designed such key-work for both oboe and bassoon. It was however Buffet¹ who did most in this direction. In 1844 a patent was granted to Buffet for a ring-keyed clarinet following the revolutionary ideas of Klosé (see p. 50), and in the same year an oboe on the same lines was designed. The first instruments made according to Boehm's direction were taken up by A. J. Lavigne², and by Paris oboist Soler³.

An important characteristic of Boehm's oboe was the use of much larger holes and a wider bore (4:35 mm at the top compared with 4:2 mm as used by Brod or Triébert). Lavigne's holes were even larger and as a result he achieved a very powerful tone. Although the larger and open tone of Boehm's oboe had not usually been popular in orchestral circles, it remained in use in the field of military music. In 1880 Lorée began to make a normal oboe with key-work adapted to Boehm fingering and other makers have since followed suit. Such instruments are mainly used by players who change rapidly between flute and oboe, or oboe and saxophone. The latest development in this direction is the saxophone-fingered oboe, on which all holes are covered by finger-plates and all keys are shaped to feel like the saxophone ones.

Special mention should be made of the German oboe after Sellner. The tone of the Sellner-type instrument was already favoured in Germany, and makers found no need for basic changes in the size and the shape of the bore.

1. Buffet, A. Jane (1831-1885). The founder of the famous Paris firm Buffet-Crampon in 1836.

2. Lavigne, Antoine Joseph (1816-1886). French oboe player. After playing first oboe for several years at Théâtre-Italiens, in 1844 he moved to England where he spent his last forty-five years (for several years he was also a member of the Halle Orchestra in Manchester).

3. Soler, Pierre Raymond (1810-1850). Born in Spain, he completed his musical education in Paris. After obtaining his first prize on oboe from the Paris Conservatoire in 1836, he joined the Opéra-Comique. Soler was an enthusiast of the Boehm oboe.

The Germans were very fond of this type of oboe which could blend in an ensemble and also had qualities as a solo voice. The bell remained wide and flared with a heavy inner rim and a very pronounced step where it met the middle joint. Sometimes there was also a step between upper and middle joints, usually smaller than the French one. Before 1900 leading German makers used a smooth bore without steps, rather wider at the top than the French pattern (about 4:4 mm against the French average of 4:2 mm).

The key-work of the German oboe during the fifty years after Sellner does not require much comment. On the whole players remained content with the capabilities of the instrument, the only dissatisfaction seemed to be the use of the left thumb for the low B natural. Ulmann¹, like Koch², made an elegant version of the thumb-key which was hinged to fold away when the instrument was packed in its case, but other instrument makers abandoned it and transferred the lever to the left little finger. The old-fashioned wooden blocks for the pivots remained in favour for a long time and they were regularly strengthened with metal lining. By 1860 the F# with an axle and two rings for the right hand was fitted. The third and most important concern of German oboe-makers in the nineteenth century was that of tuning. The Koch-Sellner model included a tuning slide in the original design and in Ulmann's model, it was adjusted by a fine-pitched screw. Other makers provided sets of two or three alternative upper joints of different lengths.

In the twentieth century the French oboe has progressed along two different lines: firstly in the direction of a more powerful tone, and secondly towards a still greater mechanical facility. Many modern players, in France especially, have felt that late instruments by A. Lorée were rather reticent in the lower register, and several makers have tried once again to redesign the tube. The newest oboes tend to show a slightly larger bore and the upper joint is being made with considerably thicker walls. In addition, the tube is longer so as to produce the low B flat. The purpose of the extra length is to steady certain of the upper notes and make them easier to attack. Some of the extreme high notes are also rendered more certain by the provision of the third octave key.

On the contemporary scene the Lorée seems to be very popular in the United States, followed by Laubin and Cabart³.

1. Ulmann, Joseph Tob. Highly esteemed Viennese maker, active from c. 1830 until 1851.

2. Koch, Stephan (1772-1828). Celebrated Viennese maker who produced the first Sellner oboes.

3. Laubin, Cabart, Marigaux and Rigoutat. Along with Lorée, the most famous oboe firms in the world; they all represent the Conservatoire system upon the influence of Gillet.

In France and Germany the most played oboes are those of Marigaux and Rigoutat (see page 35), definitely rather heavier instruments in comparison with the Lorée types.

The position of the German oboe today is quite ambiguous. Even from 1925 the famous house of Heckel¹ was obliged to begin working to French dimensions. The last stronghold of the simple Austrian-type oboe has been Vienna. The tradition is so strong that even the leading players of the famous Philharmonic Orchestra remain faithful to a fifteen-keyed instrument, not much improved from the Sellner's model. The main additions are the "spectacles" for the right hand F#, the second octave key and the half-hole plate. Sometimes this plate is duplicated by an independent key, and the octaves are linked to operate automatically. It has also a special key for F#3 (third octave) which corresponds more or less to the third octave key of the French oboes. Heckel had also perfected an arrangement in which all three octave keys operate automatically with the use of only one touch-piece. The low B flat is provided, and the thick inner rim and tuning holes in the bell are omnipresent. One of the best makers of Viennese oboes have been Stecher², Hermann Zuleger³ and his successors. They also persisted in retaining the eighteenth century baluster at the top of the upper joint, on the theory that a large mass of wood there makes the tube less susceptible to changes of temperature in its most sensitive region.

1. Heckel. German family of instrument makers. Johann Adam (1812-1877) was very famous for his contribution to the improvement of the bassoon.

2. Stecher, Karl (1820-1904). Viennese woodwind instruments maker. He founded the firm in 1865.

3. Zuleger, Hermann (died in 1958). One of the most famous Austrian-type oboe makers from Vienna. He started his firm at the end of the eighteenth century.

Intonation on the Oboe

Good intonation on oboe, depends upon a number of factors which are all extremely important, and if one of them is neglected all others will suffer. Some methods of controlling the pitch can be used *before* playing and some can be used *while* playing.

Before playing, the oboe player can alter the strength or length of the reed, adjust the length of the tube and adjust certain keys and pads. If the oboe is flat, a small piece may be cut from the tip of the reed, thus shortening the column of air. Many times a reed, which is too stiff, will cause overblowing, biting or forcing. By refacing the reed the pitch will be lowered and also the low notes will come out more easily. By adjusting the length of the tube, only when the oboe is sharp, the player actually lengthens the column of air by pulling the staple slightly out. Care should be taken not to pull it out too far because it may make the oboe out-of-tune with itself. When an open pad remains too close to the hole, it will make that note flat, and if the pad opens too much, it will make the note too sharp. Many times this fine adjustment should be done very carefully because sometimes by correcting one particular note one can spoil the intonation of other notes.

While playing, the most important factors for good intonation are abdominal support, air speed, the amount of reed in the player's mouth, tonal focus, angle of the oboe and the position of the jaw. A least satisfactory way to control the pitch is by pinching and relaxing the lips. This technique may improve faulty pitch but it affects the uniformity of tone. Once a normal amount of pressure has been determined, every effort should be made to keep from changing it. Most beginners pinch the lips for high notes, which leads to extreme sharpness of pitch.

Abdominal support

A continuous flow of air, supported by the abdominal muscles, is one of the many techniques to be perfected by the oboist. Lack of support allows the pitch to waver and often encourages movement of the lips or jaw. If the lip or jaw is allowed to move around, the tone will be delayed and will lack uniformity.

Air speed

The stream of air, which supports each note must move fast. The speed of the air increases in direct proportion to the amount of support from the abdomen.

Fundamental tones may appear to sound better with a slower air stream but, as one ascends the scale, a fast stream becomes more and more critical. The point is not that air speed should be increased for an ascending scale but that tones in all registers demand a fast column of air and will respond in tune with no variation needed. Care should be taken not to confuse air speed with dynamic control. Since altering the speed of the air will alter the pitch, one must not make dynamic changes by tampering with the speed of the air. Dynamics are controlled at the tip of the reed by the corners of the embouchure, enveloping more or less of the reed.

Amount of reed in the player's mouth

Putting too much of the reed in the mouth makes the overall pitch too high and also affects the pitch of every interval. Not matter how good the breath support; if too much of the reed is in the mouth, it is impossible to achieve good intonation without humouring every note.

Tonal Focus

The air column should be focused on low D, the fundamental of the oboe's natural scale. With this focus upper tones will have virtually perfect intonation, just as upper partials of a harmonic series generate from any given fundamental. If the fundamental register is in tune, the upper register will also be in tune. Low tone focus also helps facilitate an open, relaxed throat, a very important element in wind playing. If the low register sounds flat, it is likely that the upper register is focused too high, since low tones are virtually inflexible. Or the reed itself may be flat and should be tuned to the instrument. When a tuning discrepancy is discovered between the high and low registers, methods of tone production must also be carefully examined.

Angle of the Oboe

When the oboe is held too high or the head too low, the tone will sound faulty and out-of-tune, as if there was insufficient air support or a slow stream of air. Ideally, the oboe should be held at an angle of forty-five degrees with the elbows falling relaxed at the player's side. The head should be erect with the chin horizontal to the floor; the reed should rest against the lower jaw, which serves as a stabilising factor.

Position of the Jaw

The lower jaw should be pivoted forward enough to correct the usual overbite. A receding jaw will produce flatter tones as the scale goes up.

If the jaw is too far forward it will choke off the tone.

One must realize that each of the techniques discussed above is interconnecting, dependent upon the others. Failure to correctly use just one will result in poor intonation. At all times the tone should sound free and in tune (whether loud or soft) anywhere on the instrument with a *cantabile legato* over all intervals. Correct playing must prevail at any cost, until the supporting and controlling muscles have gained sufficient mastery to produce a constant intonation.

Here is a chart with some out-of-tune notes on the oboe. The measurements were done on oboes made by Loreé, Marigaux, Rigoutat, Buffet-Crampon and Lignatone.

B flat1	- 10
B natural1	- 10
C#1	- 10
D1	-10 to 15
D#1	- 10
E1	- 10
F1	- 10
F#1	- 10
G1	-10 to 15
C#2	+10
E2	-10
D#2	+10 to 15
F2	-10 to 15
A2	+10 to 15
A#2	+ 10
C3	+ 10
D#3	+ 10

All notes above D#3 have a considerable tendency to sharpness.

As one can see from the above chart, the tendency of oboe's pitch is to be slightly flat in the low register and sharp in the high one. Probably the most out of tune notes on oboe are D1, G1, E2 and F2, which are all quite flat. A suggested fingering would be the use of harmonics, since they are helpful for so many high notes, soft passages and trills. By using the harmonic fingerings the oboe works somehow like the clarinet and overblows a twelfth (see Clarinet, p. 54).

In the following chart there are some suggested harmonic fingerings, which will stabilise some of the sharp notes on the oboe and make easier the control of the intonation in extreme dynamics.

These fingerings are mostly done by the use of the octave keys or half-hole:

B flat1	add 1 st octave key	sounds F2
B natural1	add 1 st octave key	sounds F#2
C1	add first octave key	sounds G2
	or	
C1	raise 2 nd left finger	sounds G2
C#1	add 2 nd octave key	sounds G#2
D1	add 2 nd octave key	sounds A2
E flat1	add 2 nd octave key	sounds B flat 2
E1	add second octave key	sounds B2
F1	add 2 nd octave key	sounds C2
F#1	add half-hole (used for C#-D trill)	sounds C#2
G1	add half-hole (used for D-E trill)	sounds D2
G#1	add half-hole and low C key	sounds D#2
A1	add first octave key and half-hole	sounds E2
C#2	raise 2 nd right finger	sounds C#3
E flat2	raise first right finger	sounds E flat 3

E2 will be more in tune if one uses the 1st octave key, half hole and 2nd finger. This harmonic fingering is exactly like that for A1, with the exception of the octave key and half hole.

Cor Anglais

There is no doubt that instruments pitched a fourth or fifth lower than the treble were used before the end of the seventeenth century to complete the harmony of the oboes. The cor anglais is pitched in F, a fifth below the oboe.

The first recorded reference to the cor anglais in an orchestral score is in Purcell's *Diocletian*, in 1691. The instrument was also mentioned in Germany around 1720, as Wald-hautbois or Jägd-hautbois. Bach, who used it in his Cantatas and Passions, italianized the name to *oboe da caccia*. In Zedler's *Universal Lexicon* of 1735, it is stated that Jägd-hautbois were taken out on hunting parties, and played in the mornings and evenings before the quartets of the Master of the Hunt. There are no written particulars of the instrument's shape, but a few collections possess specimens of a tenor oboe built in a curved hunting-horn shape. There is a pair of *oboi da caccia* at Bologna, of some soft wood planed to an octagonal cross-section, rather like an old cornet with wide, bugle-like bells.

From 1760, the term *oboi da caccia* was replaced by *corni inglesi*, especially in Viennese scores (e.g. in Gluck and Haydn), and a number of these late eighteenth century instruments are preserved. Most of them are Viennese or Italian and all are curved in shape, always with bulbous bells. A characteristic of the curved cor anglais is that it could only produce a soft tone, more velvety than that of the oboe. It is very much like the sound of a distant horn. In the famous cor anglais solo from the *William Tell* overture, in the curved shape Rossini would have known, the idea is to imitate the *Ranz de Vaches* on a distant alpenhorn, an instrument that plays at almost the same pitch as the natural French horn does.

There is however a mystery why the "hunting oboe" became the "English horn". The instrument itself had no special connection with England. An explanation could be that, after the middle of the eighteenth century, the Flügelmeister's metal bugle became characteristic of the English and Hanoverian light infantry and Jäger regiments and was described in the latter as *Horn*.

The cor anglais was usually made in three sections with a separate bell joint and a small metal crook. Normal oboe features, such as tuning holes in the waist of the bell and twinned finger-holes, were regularly present.

The modern straight cor anglais was conceived more simply, and Brod (see notes on p. 30), its inventor, described it as a hautbois alto. The old curved instrument was a typically Romantic creation of the eighteenth century; the new straight cor anglais, a typically technical creation of the nineteenth century. In Italy, however, the curved instrument lasted until modern times; some players used it even until the beginning of the twentieth century.

Intonation on the Cor Anglais

The general principles involved in playing the cor anglais are the same as playing the oboe, but taking into consideration the fact that the cor anglais is a larger instrument, certain slight modifications of control are necessary.

Control of the air stream

Because it is a bigger instrument than the oboe and has a bigger reed, the cor anglais uses a slightly larger air stream at a relatively lower pressure. Accordingly the breathing and embouchure muscles must slightly modify their control. Certain aspects of playing are more difficult than on the oboe, others are simpler. For instance, the control of tone, dynamics and intonation is easier on the low notes of the cor anglais, but more difficult in the upper register.

Reeds

The reed of the cor anglais is larger, and the cane used for it is of a thicker gauge. As a general rule, one should use a slightly thicker reed and a more open one to accommodate the larger air stream and correspondingly slacker embouchure. Wire is regularly used to control the opening.

Crooks, pitch and intonation

A crook can often make a great difference to the tone and the intonation of an instrument as well as to its pitch. If one's cor anglais is unsatisfactory, it is worth the experiment of playing it with various crooks, before changing or altering the instrument itself. In cold weather the crook should always be kept warm before playing in order to prevent excessive condensation of moisture from the warm breath. The cor anglais being larger needs more warming than the oboe before it is up to pitch in a cold atmosphere. Unfortunately the oboe player is often expected to pick up the cor anglais and play a solo on it without being able to warm the instrument beforehand.

The tone of the cor anglais being naturally less bright than that of the oboe may tend to sound flatter to the ear than it actually is. A solution would be to have a short crook, which would make the cor anglais play appreciably sharp when warm; one would be comfortably in tune when the instrument is cold, and the pitch can be flattened by pulling out the crook. As already stated above, the intonation may be improved by using another crook.

The general quality all over a modern instrument is generally very good. The middle C is usually inclined to be flat; too thin or too close a reed will accentuate this tendency. The tone of middle C#, D# and sometimes D, is not clear, and the quality can be improved by using the first octave key instead of, or even as well as, sliding or lifting the first finger of the left hand. On some instruments a poor middle E may be improved by using this finger instead of the octave key. (The notes are the fingered ones, sounding a fifth lower in pitch). The top notes are frequently thin and inclined to be unstable. It is however possible to steady them by putting down one or more right hand fingers. For instance one may flatten and steady the top A by putting down the second finger of the right hand, or the top C by opening the low C natural key.

Here is a chart with some out-of-tune notes on the cor anglais. The measurements were made on instruments made by Marigaux, Rigoutat and Buffet-Crampon.

C1	- 5	
C#1	- 5	
D1	- 5	
D#1	- 5	
G1	+ 5	
E flat2	+ 5 to 10	
E natural 2	+ 5 to 10	probably the most unstable note (sharp on most cor anglais).
G2	+ 5	
A2	+ 5	
C3	+ 5	

The last top notes present a considerable tendency to sharpness.

The Oboe d'Amore

The origin of oboe d'amore is quite obscure, but it has been suggested that pitched in A, it was firstly used as a lower alternative to the C instrument. The suffix d'amore or d'amour seemed to be applied to woodwind in general when pitched a minor third below the standard instrument. The name was also associated with the more mellowing effect of the tone, apparently because of its bulbous bell. The oboe d'amore is said to be invented around 1720 in Germany. From the eighteenth century at least a dozen oboes d'amore survived, mostly German and most of them coming from Berlin. These have bulbous bells, but some French instruments by Bizet¹ have oboe-like bells.

This favourite instrument of Bach and Telemann became forgotten in the Classical period but, was revived for the performance of Bach's works in 1878 by Mahillon² of Brussels. Mahillon's first oboe d'amore had an ordinary oboe-shaped bell, like some original eighteenth century French instruments in the Paris Conservatoire Museum. It is pitched in A, a minor third below the oboe, and has a slightly bent metal crook like the cor anglais, but shorter. Mahillon fitted the normal simple-system key-work and added the low B (sounding G#). About ten years later, Lorée in Paris began to make it as it looks today, with bulbous bell and full mechanism.

After Bach, Telemann and his contemporaries, the oboe d'amore was not used for a very long time until Richard Strauss once again made use of it in his *Sinfonia Domestica*, Debussy in his *Gigues* and Ravel in the *Bolero*.

Intonation on the Oboe D'Amore

The oboe d'amore has quite a uniform scale with few notes being slightly sharp (+5) or slightly flat (-5), which is not really disturbing for the ear. There are actually only two notes, G#¹ and G natural², which have a stronger tendency to sharpness.

1. Bizet, Charles (active from 1716 until 1752). Maker of woodwind instruments in Paris. He was received into the Society of Master Instrument Makers in Paris in 1716.

2. Mahillon. Belgian family of woodwind instrument makers. Charles Mahillon (1813-1887) founded the family business in Brussels in 1836 and became famous for the excellent work he did on clarinets. In 1844 he opened a London branch which continued until 1922.

The Clarinet

The early history of the clarinet is probably, of all instruments, the most difficult to trace. Even though there are certain well-known facts about the origins of the clarinet, they are impossible to prove with any degree of certainty. The only certain fact is that its invention followed much later than that of flute, oboe or bassoon. It seems certain that for centuries, instruments of the double and single reed types existed side by side in many different cultures but it is still inexplicable why an instrument of such incredible potential failed to develop.

We know that in the Middle Ages it was the double reed, which emerged as a contrast to string and percussion instruments. Reeds were cut from tubes of different sizes and used either as an integral part of the instrument (as seen on some of the Oriental woodwind instruments, like the shawm family), or as a separate double reed, making a primitive type of an oboe and controlled by the lips of the player. One of the most important instruments in the evolution of the reed instruments was the bagpipe. Bagpipes fall into two principal classes distinguished by the bore and the reed of the chanter (the melody pipe, not the drones): with cylindrical bore and single reed and with expanding bore and double reed. The first class includes bagpipes found in Asia and North Africa, and all European bagpipes east of Germany and Italy. The second class includes all the typical Western Europe bagpipes. Ethnomusicologists often term the first kind of chanter a "clarinet" and the second an "oboe". At the same time, many single reed pipes had been used, among them the Zummarah, the Arghoul (Middle East, probably Turkey) and the Pibgorn, also known as the Welsh Hornpipe. The Welsh Hornpipe had a pair of single reeds encased in a tone-chamber, which acted as an air reservoir and also had a resonating bell at its end.

There is some mystery about the instrument, which was the ancestor of the clarinet, possibly because even though there are many drawings and paintings from the seventeenth century, nobody who lived in this century has seen one, for it does not exist in any museums or private collections. There have been some replicas of the Chalumeau, which is in a way considered the ancestor of the clarinet. The chalumeau had a single reed, a tapered mouthpiece and the player probably had to control the reed in the manner of the oboe.

The chalumeaux played an octave lower than a recorder of the same size and were required in at least four different sizes and pitches (like a consort of recorders), from soprano to alto, tenor and bass.

It is possible that the two names, "clarinet" and "chalumeau" were interchangeable for many years, while in fact there was only one clarinet used in different registers.

The invention of the clarinet is attributed to J.C. Denner (? - d.1707) of Nürnberg from around 1700. Denner was one of the leading German woodwind-makers of the end of the seventeenth century. Surviving instruments carrying his initials include one recorder of the old pattern, dated 1682, and several of the new: a shawm of the old kind and a *deutsche Schalmey* (German shawm - the ancestor of the oboe); a curtal (ancestor of the bassoon) and preserved at Munich, an elementary two-keyed C clarinet. The first reference to Denner and the clarinet is made by J.S. Doppelmeyer in his *Historische Nachricht von den Nürburgischen Mathematicis und Kunstlern* (*Historical Report of Nürnberg Mathematicians and Craftsmen*) in 1730. He wrote: "At the beginning of the present century Denner invented a new sort of pipe, the so-called Clarinette". In the same statement, however, Doppelmeyer said that: "and finally produced chalumeaux in an improved form".¹ Is this statement correct? Some researchers asked themselves where did all un-improved chalumeaux go. They have also found that Denner's "improved chalumeaux" of 1690 had a cylindrical tube with seven tone-holes and two diametrically opposed keys above of highest of these. This arrangement could not properly overblow because of the positioning of the keys, so those simple instruments had a compass of just a twelfth. The distinctive timbre of this little pipe, quite low in pitch for its short length, made it useful for operatic effects and it was also used occasionally by composers such as Telemann and Gluck. The fact remains that Denner developed the clarinet as distinguished from the chalumeau. The difference seems to be the disposition of the two keys which when properly placed, makes an instrument of almost three octaves.

There is a two-keyed clarinet in the Nürnberg museum, by Jacob Denner, a son of J.C Denner, probably made in 1710-1720. Father and son made numerous experiments to move the two keys-covered holes in order to obtain an optimum position, so that both the chalumeau and overblown register of the clarinet could have a fair degree of pitch accuracy.

1. Brymer, Jack. *Clarinet* (London, 1976) p.19.

It must be mentioned that the throat notes themselves are not perfectly placed, but such is the flexibility of that register on that clarinet, that they can be humoured into pitch by a skilled player and probably, like all woodwind instruments, that would have been the approach of the player of that period.

Denner had another brilliant idea: to combine the reed with a tone-chamber inside the tube thus bringing the reed for the first time under the control of the player's lips. That was the typical shape of the clarinet mouthpiece. The chalumeau register had a compass of nine notes: from F1 to G2. These could be modified by cross-fingerings to produce B natural, C#, E flat and F#. With the newly found resonance of his mouthpiece, Denner's intention was to extend this compass upwards. This he did by "overblowing", using the same fingerings but splitting the air-column at its upper end and by introducing a "small hole", covered or uncovered at will by a closed key. This was the "speaker-key" and from that date to present it is one of the most important keys on the clarinet.

It is not clear what Denner expected by opening this key: a new register one octave higher than the original one, like on the oboe or, judging from the odd squeak he had been able to produce without the speaker key, something different. Whatever he expected, it came as a register a twelfth above the fundamental and this meant that he had to add not one key but two to produce the notes A2 and B2, thus producing a new instrument with the theoretical compass F1 to D3. There is a specimen of one of Denner's early clarinets with two keys in the Bavarian Museum in Munich. That clarinet was obviously not capable of producing such a large compass with any degree of accuracy. The two keys are exactly opposite to each other, to be controlled by the first finger and the thumb of the left hand. The thumb key alone produces A natural and the index finger alone, B flat. Both keys together give quite a poor B natural.

The next step in the experiments of J.C. Denner and his sons was to place the thumb-hole higher and to narrow it, in order to produce the B flat, by closing both keys together and A natural by closing the index-finger alone (it approximated with the modern arrangement). This was a great advance, but had a problem: the B natural is absent, except as produced by a flattening of the overblown C, by slackening the lips. This instrument had quite a good intonation except for the cross-fingered notes and had a compass of three octaves (F1 to F4). One of Denner's sons later inserted a small metal sleeve into the speaker-hole, to improve the B flat and to prevent the collection of water in this hole. By increasing the size of the holes previously used to produce B flat and F natural the notes B natural and F# could be obtained.

The F# was good and the F natural could be obtained by a fork-fingering (2nd finger + thumb hole). The B natural was a success in the chalumeau register only because the new F# (obtained by the overblowing of B natural) in the clarinet register was very flat.

The problem of the B natural preoccupied Denner's sons for a long time and eventually in about 1740, Jacob Denner invented the third key in the clarinet's history. The way to obtain the missing B natural was to extend the compass downwards to E natural by lengthening the instrument and use the overblown twelfth to obtain B natural. The third key was for the fourth finger of the right hand or for the thumb and covered the bottom hole. The discovery of E natural gave the clarinet a complete compass of correctly fingered notes, diatonically from E1 to top C3 - almost three octaves in range and a selection of harmonic fingerings higher than that. There were, however, some problems in the chromatic scale. Some of the semitones were extremely out of tune, especially when obtained by cross-fingerings and some were completely unobtainable. By the adding of the E natural key, the clarinet became longer and had a bell at its end, which proved to be an improvement of the intonation and tone. The clarinet had in fact reached its present shape. It must be stressed that the discovery of the clarinet filled an important gap in the orchestral spectrum and its use spread rapidly throughout Europe in the first half of the eighteenth century.

Very interesting is the fact that from the very beginning clarinets were made in different sizes, giving them the facility to play in different keys, which would otherwise have been impossible. That is why clarinets have always been transposing instruments.

The next improvement in the design and intonation of the clarinet took place as late as 1760 when the five-keyed clarinet, which was soon to be in general use, appeared. The two new keys were also in the lower part of the instrument and were for G# (overblown D#) and F# (overblown C#). These keys seemed to be the results of experiments of several makers and players, notably the virtuoso Joseph Beer (1744-1812), the famous Bohemian clarinetist to whom Carl Stamitz (1745-1801) dedicated his clarinet concertos.

After that numerous experiments were made to improve the intonation rather than the technique. There were reports of a six-keyed clarinet as early as 1791 and also of one of eight keys a year later. The main problem was the leaking of the air from the felt pads, the weak springing and the generally clumsy key-disposition. The Frenchman François Simiot (1782-1839) of Lyons had a great contribution to the clarinet.

He invented the A-B trill key and by 1820 he displayed a clarinet of nineteen keys.

At this point in the history of the clarinet, a very important contribution belonged to Iwan Müller, the famous innovator and clarinet virtuoso. Müller, a Parisian born in Russia (1786-1854), gave concerts all over Europe, from St. Petersburg to Dresden, Berlin, Leipzig and Vienna. It was in 1809 that he gave a recital on a clarinet of a new design, made for him by the Viennese maker, Herman Merklein (? – d. 1824). Apparently, the new clarinet made such a sensation that Müller had the idea to establish a pattern for a large-scale production.

In 1812, Müller presented his thirteen-keyed clarinet to the Commission of the Paris Conservatoire. It must be stressed that what was important on this clarinet was the way the keys were constructed, disposed, vented and padded. Müller's invention represented the furthest advance since the work of Denner, and he claimed that his new clarinet could play in any key. His methods were also new: he improved the leaking from the pads by making countersunk holes, so they presented a raised ring to the pad. The pads themselves were made out of leather with a soft filling of wool and were held in a holder cap, which was soldered on to the end of the key in such a way that it left an opening, or a "vent" for the air to escape when the key was in open position. The disposition of the keys was much more logical than any before, and gave an improved acoustic result.

Unfortunately, the Paris Commission turned down Müller's invention. Apparently, the reason was quite a traditional one. Because Müller claimed that his clarinet could play in any key, it seemed that the only instrument for the future would be a B flat clarinet, as being of convenient size and pleasant tone. The musicians of the Paris Conservatoire believed that each clarinet had its own special character and sound, according to its pitch and therefore these musical characters should be preserved. Fortunately, Müller was not discouraged (even though he had to stop his mass-production) and during his tours through Europe, he proved the superiority of his clarinet. By 1815, he also worked on the development of the mouthpiece and reed. Firstly, he abolished the binding of the reed to the mouthpiece with a cord, replacing it with a metal ligature very similar to that one in use today. Secondly, he thinned and tapered the reed, making it responsive to the much more curved facing on the mouthpiece. This meant that he had a much better control and produced a greater variety of articulations. All things considered, Müller was a huge figure in the development of the clarinet and one important section of the clarinet design at the present time, the "German" clarinet, is founded directly upon his work

Another great innovator in the history of the clarinet was Hyacinthe Klosé¹, the inventor of what is known as the Boehm system clarinet. The basis of Klosé's work upon the Boehm's principle is that he followed Boehm's idea of large holes, properly "vented", and also the key system of a series of ring-keys by which a finger can close a ring when covering a hole and by doing so, operates another key to cover a different hole at some distance. The result was that fingers could cover holes well outside their normal reach, so that holes did not have to be made smaller or moved closer to accommodate the hand position.

After his appointment as professor at the Paris Conservatoire in 1838, Klosé presented his idea of the Boehm method of ring-keys to Louis Buffet², the famous French manufacturer. The instrument Klosé presented was the same as most of present-day clarinets. It had seventeen keys and six rings which helped the fingers to control twenty-four tone-holes. It should be mentioned that Buffet was awarded a medal for this instrument at the Paris Exhibition in 1839 (neither Boehm or Klosé were honoured). Perhaps the greatest advantage of this clarinet, except the technical facility, was the acoustic soundness of the fingerings. Another advantage is the avoidance of fork-fingering in the right-hand area. The fact that the notes B₂, C natural₂ and C#₂ could be obtained with the little fingers of either the left or the right hands, leaving the other free to move to the other notes which were obtainable only by sliding on the Müller clarinet, meant that many passages, trills and shakes were possible for the first time.

In the same time, there were several other makers who tried to improve the clarinet, one of them was the Belgian Adolphe Sax³, the inventor of the saxhorn and, of course, the saxophone. Already in 1835 he is said to have produced a clarinet of twenty-four keys, but his greatest invention took place around 1842, when he produced an instrument a step closer to the modern German clarinet. Sax retained Müller's system of fingering and added a very important pair of rings to the lower joint which improved the pitch and sound of B natural/F# twelfth.

1. Klosé, Hyacinthe (1808-1880). Famous French clarinetist. He firstly played in the Royal Guard where he also became an Army bandmaster. Later he studied at the Paris Conservatoire and in 1838 was appointed professor there.

2. Buffet-Crampon. French firm of woodwind makers founded in 1831 by Louis-Auguste Buffet (died in 1885). He realised the reform of the clarinet introduced by Klosé.

3. Sax. Belgian family of wind instruments makers. Adolphe Sax (1814-1894) played the flute and clarinet. At the Brussels Industrial Exhibition of 1835 he presented a clarinet with twenty-four keys (made in 1834). In 1838 he patented the bass clarinet that surpassed any previous models. After moving to Paris in 1842, he patented the saxophone in 1846.

From that time to the present day there have been a great number of inventors who have added to the Müller clarinet many of the advantages of the Klosé system.

One of them was Jean Albert, a remarkable instrument maker from Brussels, who remodeled Müller's clarinet during the 1840s or 1850s. Though no particular improvements were made over Müller's clarinet, Albert refined the mechanism. His clarinets were quite popular for a long time in Germany and former Czechoslovakia. As a paradox, in Belgium itself the Boehm clarinets prevailed over the Albert-system ones. The Albert-system is best known in America, and particularly in some jazz performances; however there are very few in use.

In Germany, Carl Bärmann (1810-1885) made an extension to the keys, so they could be played by different fingers. He also duplicated some of the keys so that the opposite hand could be used. There was also a considerable correction of the intonation of several notes by the use of the ring-keys. At the end of nineteenth century Robert Stark¹ experimented with some improvements, which combined the advantages of Boehm system with Müller's arrangements. The last great improvement of Müller's system was done by Oscar Oehler². After many years of experiments Oehler altered the position and shape of almost every key on the clarinet until the instrument suited the player's hand, and made it as acoustically perfect as it could be made. Oehler was very much concerned with the problem of forked notes and he worked to improve the disadvantages of Müller's clarinet, by providing extra keys.

With the consideration of the Müller, Klosé and Oehler systems it can be said that the history of the clarinet is brought to the present time, since the vast majority of the players use one of these systems. At the same time one has to mention some manufacturers that have been trying to improve the scale of the clarinet. The French oboe player Apollon Barret (see notes on oboe, p. 31) applied his invention to the upper-joint of the clarinet. He used a ring-key spring-loaded against a single side lever, which produced the notes E flat-B flat and F natural-C natural as a side-key fingering. As a result of that many trills and shakes were possible for the first time. This adaptation, however, could not apply to the Boehm system clarinet.

1. Stark, Robert (1842-1922). German clarinetist and composer. After graduating from the Dresden Konservatorium he became solo clarinetist at Wiesbaden and later was appointed professor at the Royal School of Music at Würzburg. He also composed three concertos for clarinet and a woodwind quintet.

2. Oehler, Oscar (1858-1936). German clarinetist. He started making clarinets about 1888 in Berlin. The Oehler-system is used today almost universally in Germany.

At the beginning of the twentieth century Clinton¹ of London had some success in combining the alternate levers of the lower joint (the main advantage of Klosé system) with a Müller clarinet, which also incorporated Barret's upper joint invention. He called his system Clinton-Boehm clarinet. Both Barret and Clinton clarinets have now ceased to be manufactured. From this time to the present, almost every attempt at advancement of the clarinet's acoustics has been concerned with the improvement of the throat notes B flat, A flat and A natural.

The weakness of the B flat has always been the result of the dual function of the speaker-hole: it has to produce perfect twelfths as well as the B flat note. This is theoretically impossible for as a speaker-hole it should be much smaller and placed much higher up on the instrument, while as a B flat it should be much larger and placed lower on the clarinet. In fact it should be where the side trill key of that pitch is now situated. For almost a hundred years makers have been trying to solve this problem. Among them was Ernst Schmidt² who in 1912 succeeded in producing an instrument with a separate key-opening for each purpose. Later Heckel (see notes on p. 36) refined this arrangement and also added a special mouthpiece. In 1934 Hans Berninger from Leipzig had another idea, to open the trill keys and thus to give a better resonance to the throat B flat.

In the recent years the work of William Stubbins (born 1927) of the United States needs to be mentioned, since it has contributed greatly to the improvement of the clarinet. The so-called S.K. mechanism, which he invented, improves the acoustic and quality of the throat notes. As it has been already stated, it is essential to have two holes to separate the two functions attempted by one speaker-hole: a small one higher up the tube and a much larger one further down the tube, in a position where it can produce a perfect B flat. These two holes must come into action automatically so that there is no alteration of the fingering arrangements of the clarinet. What Stubbins did was to obtain the throat B flat by the normal fingering. But the effect is very different because, in addition to the speaker-hole, a large and resonant tone-hole opens. As soon as the thumb-ring is operated to produce the clarinet register, this large hole is closed, leaving the speaker-hole open. The twelfths produced by this arrangement are far superior to those normally achieved and the B flat is much purer in sound and better in pitch than it could otherwise be.

1. Clinton, G. A. Well-known professor of oboe of the early twentieth century in London.

2. Schimdt, Ernst (1904-1960). German clarinetist and maker from Mannheim.

The history of the clarinet could not be concluded without mentioning the Mazzeo and the Double-Boehm system. For years Rosario Mazzeo (who died in 1966) played bass-clarinet in the Boston Symphony Orchestra and worked on improving the throat notes of the clarinet. In his clarinet it is unnecessary to use the normal Denner's keys for A natural and B flat because these notes can be obtained by using any of the ring-keys other than the first finger of the left hand, either singly or in any combination desired. A natural is obtained by playing open G and adding any ring, and B flat is obtained by playing the normal A natural and adding any ring from either hand. In addition to the extreme dexterity, the notes B flat, A, G# and G natural (the throat notes) are more open and better in tune, as bigger holes are used.

The area, which the Double-Boehm system tried to improve, was the left-hand tone-holes instead of the throat notes. The theory is that it is illogical to have a different sequence of fingerings to produce the same interval in each hand. In the normal Boehm system the raising of each finger of the right hand starting from the lowest, raises the pitch on the sequence tone-semitone-tone. The left hand produces tone, tone and semitone. In the normal right-hand fingering the missing semitone between the third step and the tone above is produced by a fork-fingering. In the Double-Boehm system the same layout is adopted for the left hand, so that the E natural is a forked note (second finger alone) and E flat is "unforked" (first finger). This system greatly facilitates some passages but also complicates others, like some passages in C major and its relatives and in fact adds an extra "fork" note to the acoustics of the clarinet. Acoustically the makers claim a considerable improvement in the second overblown register (fifth harmonics - from high E natural upwards), due to the more logical lay-out of the left-hand and a great increase in the brightness in the throat B flat, due to the increased size in the tone-holes of A and G#.

Intonation on the Clarinet

Before analysing some of the clarinet's tendencies, it would be helpful to present some of the acoustical problems of the instrument. As already stated above, in all woodwind instruments the air column inside the tube vibrates, creating waves. Whatever the shape of the tube, it is essential to have an external source of vibrations to excite the air column. In the clarinet, oboe and bassoon there is a reed, which starts vibrating the air column inside the instrument. The reed acts simply like a valve - opens and closes the air supply to the column inside the tube. The oboe and bassoon reed is a self-contained generator of sound while the clarinet reed on its own is silent.

The generator of the clarinet is the complete mouthpiece with the reed attached to it. It has been found that the lowest or the fundamental sound produced depends on the capacity and the shape of the tube¹. The larger the cavity the lower the sound and cavities of different shapes give different forms to their waves. As the clarinet presents a cylindrical cavity it gives the instrument the characteristics of a "stopped-pipe". The most obvious characteristic of a stopped-pipe instrument is that the pitch of its fundamental note is very low, comparative to such a short tube. That gives the clarinet its first big advantage, an extremely large compass. However it also gives it quite a disadvantage: as it produces such a low note from a relatively short tube, the scale upwards from this must have subdivisions which are small and critical in the calculation and construction of the holes.

Another important characteristic of the stopped pipe instruments refers to the harmonic spectrum. As it will be discussed in the last chapter (page 90), the first seven harmonics of the fundamental are octave, fifth, fourth, major third, minor third, minor third, major second. When playing the lower C (the written note, not the concert pitch) on the clarinet it is possible to obtain by lip pressure, only harmonics 1, 3, 5 and 7. It is impossible to obtain numbers 2, 4, or 6. It should be noticed that harmonic 7 turns out not to be a B flat as it should be in theory, but a well-tuned A natural (actually it is a very flat B flat). An observation should be made that in the case of the clarinet the harmonics are helped by the use of the speaker-key and many of them by raising the first finger of the left hand. Reconsidering the first harmonics of the clarinet, the first jump is a twelfth and the second a sixth above that. The twelfths are usually acceptable but the sixths are not. They also vary not only according to the length of the tube, but from clarinet to clarinet.

The second overblown series also varies in respect of various tapers clarinet makers use to introduce into the bore in order to correct the important relationship between the chalumeau register and the twelfths above it. As a result most of the twelfths are fairly correct and acceptable without any change of fingering. The bell B when overblown produces a G natural which should sound a G# and the A natural harmonic of C natural which is usually poor. It is only with the harmonic of E (the usual top C#) that the overtones have been properly considered. However this note on some clarinets is very flat and has to be raised by pressing the E flat key. The same applies to the top D, the harmonic of F below and to E over the G.

1. Nederveen, C. J. *Acoustical Aspects of Woodwind Instruments*. Chapter 2; Clarinet

The top F natural above A flat reacts differently, influenced by the size of the bore: it tends to flatness in the case of a small bore and to sharpness in the large bore. Sharpness is not as difficult to correct because one can ease the embouchure downwards, but it is almost impossible to make it higher by lip-pressure alone. The harmonics on the B flat² (third harmonic) should theoretically be a top G but in most large instruments it is a very good F# and should be used more often. The harmonic on B natural² in the clarinet register is one very flat fifth harmonic. It should be a G# in theory but again it is a very good G natural in many clarinets. It should be mentioned, however, that in small-bore clarinets it is a very flat and poor note.

Special mention should be made of the importance of the mouthpiece and the barrel regarding the intonation. Clarinetists recognise that the mouthpiece and the reed are the heart and soul of the clarinet. The most important characteristics of a good mouthpiece are: the material used in its construction, the length of the facing, or the lay, the amount of opening at the tip of the reed, and the combination of factors of facing and opening. The huge majority of players agree that the best results are obtained with a hard rubber mouthpiece, against the crystal (glass), wood or plastic. Regarding the facing or lay, most clarinetists agree that extremes in facing and tip opening should be avoided, and a uniform combination of facing and tip opening is desirable – a medium short facing requires a medium close tip, and a medium long facing calls for a medium open tip. It is also extremely important to use a mouthpiece with an exactly matching bore size, if possible. Another reason for distortion could be a mouthpiece with a small bore tone-chambers. The small bore produces a brilliant tone but tends to sharpness. To play in tune, some inexperienced players pull out the mouthpiece, the barrel or other joints, and create an “out-of-focused” instrument. The importance of the bore cannot be underestimated. Although the small bore is preferred by some professional players, it would be advisable to compromise and balance a medium lay with a medium bore.

Although great progress has been made in producing a better mouthpiece, a solution to improve the tone and the intonation lies in the barrel-joint, the most neglected, and one of the most important parts of the clarinet. The proximity of the barrel to the mouthpiece makes it the most important point in the bore of clarinet. Any minute change in the diameter if the bore is discernible in the intonation and the quality of the tone. Excessive moisture and climate conditions could cause the barrel to become warped or to expand beyond its original dimensions.

The reason for all these changes is the natural tendency of the wood to be affected by moisture and climate changes. Evidently, a solution would be that a more stable material should be used. Apparently, the most suitable material available would be a hard, rod rubber, whose dimensions will remain true, regardless the degree of moisture or climate changes. A barrel of correct and accurate dimensions in addition with a well-balanced mouthpiece will improve greatly the intonation of the clarinet

Addressing the clarinet intonation, special attention should be given to the throat notes G, A flat, A natural and B flat. From these notes the B flat is probably the worst note on the clarinet, from reasons already mentioned above (the faulty dual purpose of the tone-hole speaker-key). Even though this problem was partially solved by Stubbins and Mazzeo, most clarinets are without such acoustic advantages. As already mentioned, the B flat tone-hole should be bigger and farther down the clarinet, where the present B flat trill key is, and of that size. A simple solution would be to use this trill key as a melodic note instead as a trill one. The technique would be to touch the key with the second joint of the right first finger, because it is unnecessary to remove the fingers of the right hand from the holes and keys of the low joint. When it is impossible to use the trill key a suggested fingering which seems to work on most clarinets for B flat² is:

LH: Sp-A key-2-3-C# key / RH 2-3-F key.

There are some suggested fingerings also for A natural, A flat and G natural.

For A natural: LH A key-2-3/ RH 2-3-F key.

For A Flat: LH A key-3 / RH 1-2.

To improve the quite dull open G natural there are two suggested fingerings:

LH open/ RH 1-2-3-F key or LH 3 / RH 1-2.

(For all suggested fingerings a clarinet chart is shown on page 58A).

It would also be helpful to consider the effect the misplacement of the speaker-hole has upon the twelfths of the clarinet. It has been found that twelfths farther down the instrument are usually narrower and those further up are usually wider. That theory poses some problems to the clarinet makers; if they are more concerned that the chalumeau register be perfectly in tune, the clarinet register would be very flat at the bottom and extremely sharp at the top.

Evidently the opposite applies: if the clarinet register is regarded as more important, the chalumeau register would be so out of tune that it would be difficult for beginners to control it.

Numerous experiments have been made from Denner's time and eventually the solution found has been a compromise one, with bore-sizes and tone-holes disposition, which make the clarinet tolerable in both registers. The twelfths are far from perfect and would be a subject of improvement for future generations. It should be stressed that these imperfections are present on almost all clarinets, to a lesser or greater degree, and ultimately it is the task of the player to improve it.

The first and most obvious method of affecting the pitch of a note is the embouchure control, tightening or slackening the embouchure to sharpen or flatten the pitch. The procedure allows the reed to vibrate and corresponds to the basic laws of acoustics, when a small vibrating body has a higher frequency than a larger one and therefore produces a higher pitch. However, it has been experienced by most of the players that it is much easier to slacken the embouchure to lower the pitch (sometimes even by a semi-tone) than to tighten it to raise the pitch.

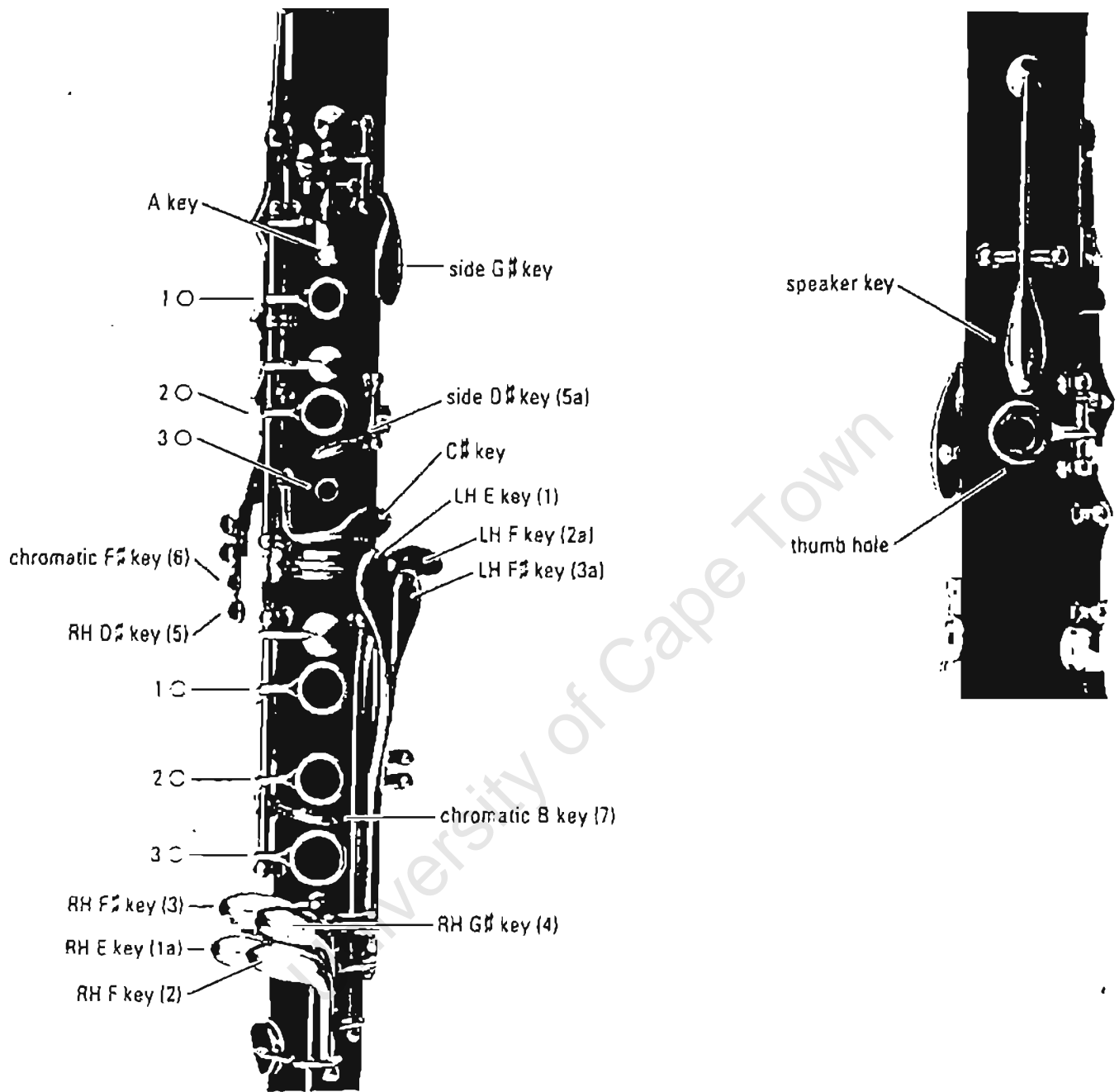
As a general rule the low notes on most B flat clarinets are sharp but sometimes E1, F1 and F#1 can be quite flat. The sharpest notes on most clarinets seem to be the E1 and its overblown B2. The very high notes have a strong tendency to be flat or unstable. However, the author has had a Buffet clarinet tested whose high notes (from D3 to F#3) were quite sharp. Embouchure control should not be the only method when dealing with pitch and especially in the upper register the use of alternate fingerings is recommended.

In the following chart some alternate fingerings are suggested but they should be taken mainly as guide, since not only there are different makes of clarinets, but also individual instruments vary differently.

The measurements were made on clarinets made by Yamaha, Selmer, Buffet-Crampon and Boosey & Hawkes.

E1	+10 to 20	
F1	+	or on some clarinets quite flat
F#1	+	or sometimes quite flat
G1	+10 to 20	
A1, B flat1 and B natural1		usually sharp. To flatten add RH F or E key
C#1	+	
D1	+20	To flatten add RH 2 or 3
D#1	+15 to 20	Add RH 2 and 3
E2	+ 20	or sometimes flat. To sharpen add RH D# key
F2	+20	
F#2	+20	
G2	+	or sometimes flat
G#2	+	
A2	+	
A#2	+	
B2	+20	Normal fingering plus G# key
C2	+15	
C#2	+	
D2	+10	
D#2	+15 to 20	To flatten add LH F# key
F3	+	
F#3	+	
G3	+	
A3	+	
A#3	+	
B3	+	
C#3	+	
D3	+	or sometimes flat
D#3		one of the most variable notes on the clarinet
F4	-	
F#4	-	
G4	-	
A4	-	

These are some out-of-tune notes on the B flat clarinet Boehm system. As a general rule the A clarinet has the same pitch tendencies, but according to the discussions the author has had with most clarinetists, its normal pitch is slightly higher than the B flat clarinet.



Key to symbols

LH	left hand	RH	right hand
●	cover hole	O	leave hole open
Th	cover thumb hole	Sp	press speaker key
1	press LH E key	1a	press RH E key
2	press RH F key	2a	press LH F key
3	press RH F# key	3a	press LH F# key
4	press RH G# key	C#	press C# key
5	press RH D# key	5a	press side D# key
6	press chromatic F# key	7	press chromatic B key
A	press A key	G#	press side G# key

The Bass Clarinet

The documented history of the bass clarinet belongs to an announcement in the Paris newspaper, *L'Avant-Coureur*, of 11 May 1772, saying: "Mister Gilles Lot, maker of woodwind instruments has invented a new instrument, called bass tuba or bass clarinet. We have never seen an instrument with such a large compass: it descends as low as the bassoon and it goes as high as the flute."¹ If the documented history begins in 1772, the undocumented history begins much earlier with quite a primitive instrument by an unknown maker constructed of plankwood and covered with leather. There are two specimens, which have well survived, one in the collection at Berlin Hochschule (2810) and the other one in Brussels Conservatoire (939). The first has only one key and the second, formerly owned by Adolphe Sax, has three keys. Both are essentially identical in design. The Berlin specimen was probably made before 1750, and the only key is designed to give the bottom note only. In the Brussels specimen there are three keys: two are for the first finger and thumb of the left hand and the third for low E is mounted on the left side and manipulated by the little finger of the same hand. This instrument was intended to overblow and to have a clarinet register.

The next model to be mentioned is the bass clarinet of Heinrich Grenser (1764-1813), the famous Dresden maker who contributed to the development of the five-keyed clarinet. This clarinet had probably a military purpose, to replace the bassoon in military bands with a greater sonority. Only one specimen has survived and is preserved in the Darmstadt Museum, Germany. It has nine keys; it descends to B natural below the bass staff and has a compass of four octaves.

The next date of importance is 1807 when Desfontenelles² devised an instrument of modern appearance. Only one specimen has survived and can be seen at the Paris Conservatoire Museum. Because of the resemblance to a saxophone there was a good deal of speculation until it was proved that the instrument overblows not in octaves but in twelfths, as does the clarinet. It had thirteen keys, a remarkable anticipation of Iwan Müller's invention, and the keys are mounted between pillars. An important device to every key is the pillar upon which it pivots. The pillars are screwed into the wood very firmly, and the alignment of this help, the keys to work smoothly. This is the first time that pillars were used on the clarinet.

1. Constant Pierre, *Les Facteurs d'Instruments de Musique* (Paris, 1883) p.103.

2. Desfontenelles. Known only by his surname. French clarinetist and woodwind instrument maker who had his workshop in Lisieux from about 1790 until about 1824.

Exactly contemporaneous with the invention of Desfontenelles was that of Dumas. He was a French clarinetist as well, known only by his surname, as Dumas of Sommières, and in 1807 he presented his bass clarinet for trial to the Paris Conservatoire. The Commission accepted and recommended it to the Royal Guard. However, the reason the instrument was not accepted seemed to be that the artists of the Guard, used to the six-keyed clarinet, were not happy to change and to learn a new instrument with thirteen keys.

Some inventors have tried to shorten the tube and to bring the tone holes within the reach of the fingers. One of them was the Italian Nicola Papalini, clarinetist and clarinet maker active near Pavia, circa 1800. Around 1810, this maker provided an ingenious solution of shortening the tube. The bore of the instrument, pitched in C, is curved and fingers stop some of the holes normally fitted with keys. There are sixteen tone-holes of which five are closed with keys. The bell is turned towards the player's right, and a double-coiled crook, made out of wood, brings the mouthpiece to the lips. The compass is extended to C and is not covered in leather. Five specimens have survived, and it is definitely a portable model, but tone and intonation have been sacrificed to compactness.

In 1812, another bassoon-shaped model appeared, the bass-organ of H. S. Sautermeister, a famous French instrument maker from Lyons. That instrument had a perfectly cylindrical bore, resembled a bassoon, and had a compass of more than three octaves, descending to low C.

Another bent-up model was introduced in 1828 by Gottlieb Streitwolf¹ of Göttingen. It was made of boxwood and was extended to C or to B flat. It was pitched at first in C and later in B flat, and had seventeen, eighteen or nineteen keys. There has been a romantic story that Dumas kept his clarinet to himself and only when he was dying in 1832, gave the instrument to a very well-known player Dacosta². What is significant is that just about this time, 1832, Dacosta was co-operating with Buffet (the famous clarinet maker) in the production of a bass clarinet and gave a recital on this new instrument. The Dacosta-Buffet model had a compass of three octaves and a third, a straight body and a curved crook, which carried the mouthpiece towards the player. Apparently it was for this instrument that Meyerbeer (1791-1864) wrote the famous solo in his opera *Les Huguenots*.

1. Streitwolf, Gottlieb (1779-1837). Well known clarinet maker from Göttingen, Germany.

2. Dacosta, Isaac Franco (1778-1866). French virtuoso clarinetist of his time and also an early virtuoso on bass clarinet.

The next instrument, which obtained considerable success, was made by the Italian Catterino Catterini, a woodwind instrument maker active near Padua in about 1838. This instrument was made from a single block of boxwood of oval section. Two parallel bores are pierced in it in the manner of the butt-joint of a bassoon. A long brass crook carries the mouthpiece, while the other end of the bore terminates in a widely upstanding bell of wood. There are twenty-four brass keys mounted in saddles which cover correctly located tone-holes of right sizes. This instrument (which belongs to the Brussels Collection) is pitched in C and descends to low C.

Almost in the same time, precisely on 19 June 1838, a new bass clarinet was perfected by Adolphe Sax, who was not only an inventor and craftsman of high ability, but also a brilliant clarinetist. The new bass clarinet has a straight body, accurately-placed tone-holes, each covered by a padded cup and, most important of all, the additional speaker-key near the mouthpiece. Every hole was brought comfortably under the fingers by a mechanism, and the new instrument was provided with the usual metal crook and downward-pointing bell. The compass was increased at the top by the second speaker-key and descended to the low E sounding D. A metal reflector could be fitted to direct the lowest notes in any desired direction, or a curved bell could be fitted extending the downward range to low C. The four additional holes were located on the long neck of the bell. The new instrument won immediate success in Brussels and later in Paris. With the gradual adoption of Sax's straight-bodied model with covered holes, the history of the development of the bass clarinet was almost complete.

The instrument of the present differs little from the early model of 1838. The mechanism has been modernised, the crook has been given a more graceful look, and the mechanism of the Boehm system clarinet was soon applied to it. As a general rule Sax's model has never been too popular in Germany as the bore was considered too large, the tone too hollow and too vigorous for orchestral use. German makers have always preferred a thinner, slighter model with a smaller bore and played with a smaller reed and mouthpiece. The more elaborate forms of Oehler mechanism are fitted to it and may have as many as twenty-seven keys. They also use a foot-peg. Nowadays the German or French models are fitted with automatic speakers. There is also a modern German design, which uses three speaker keys, all changed automatically. Referring to the lowest note on the bass clarinet, in orchestral works the bass needs to go down to the low E flat to reach the bottom E of parts written for almost extinct bass clarinet in A.

On the contemporary scene, instruments have been built in Germany or France, to reach the low C, to accommodate the parts written by Stravinsky, Khatchaturian or Shostakovich.

Intonation on the Bass Clarinet

As a general rule the low notes on most B flat bass clarinets are flat. The chalumeau register is quite in tune and it is possible to produce a lovely tone. The throat notes and the middle and top registers usually present some problems. One of the flattest notes seems to be the low E (about 20 cents too low). On the sharp side E2 is almost 20 cents too high, followed by G2, G#2, A2, A#2 and B2 (which is E1 overblown), which are all around 15-30 cents too sharp. At the top register the tendency is to be very sharp, and alternate fingerings should be used. Most of the methods and alternate fingerings, used to improve the intonation of out-of-tune notes on the clarinet, can be used for the bass clarinet.

Here is a chart with out of tune notes, noticeable on bass clarinets made by Buffet and Selmer:

C#1	-20
D1	+
E1	-20
F	-5
G	+
G#	+
C2	+
D2	+5
E#2	+20
F2	+10
G#2	+10 to 15
A2	+15
B flat2	+20
B 2	+20 to 30
C3	+20
D3	+
E3	+
F3	+
F#3	+
G3	+
A3	-10 to 15
A#3	+10 to 15
B3	+20 to 30
C4	+20 to 30

All the notes above that are quite sharp and unstable.

The E flat Clarinet

The history of small clarinets can be traced to the beginning of the nineteenth century when the F clarinet was used in large military bands. Almost at the same time a small clarinet pitched in D was used in Germany by military bands and was also used by Wagner in his operas. Very much used in military bands, the E flat clarinet was brought into the orchestra by Berlioz (1803-1869) in his *Symphonie fantastique* in 1830. It did not have an important place in the orchestral repertoire however until Mahler's first symphony. It is very interesting to mention that Richard Strauss also used the D clarinet - and even today there are some orchestras, which prefer the tone of the D clarinet.

Intonation on the E flat Clarinet

The E flat clarinet is pitched a fourth higher than the B flat clarinet and sounds a minor third higher than the written note. It extends the range of the B flat clarinet upwards almost one octave. As the E flat clarinet offers considerably more resistance than the B flat clarinet, a well-developed embouchure is required to be able to adjust to the smaller mouthpiece. Actually for playing and controlling the E flat clarinet one has to practise it like any other instrument. One has to know all the difficulties of the instrument and should be able to control and correct all out-of-tune notes. Another difficulty of playing the E flat clarinet lies on the fact that sometimes a player has to switch quickly from the normal clarinet to the E flat one, as, for example, in Berlioz's *Symphonie fantastique*. That is the reason the E flat clarinet is treated, in some orchestras, as a solo instrument and it is required from the alternate principal player to double on it. The main intonation problem of the E flat clarinet is its top register, which is generally extremely sharp. Most of the alternate fingerings of the clarinet also work well on the E flat clarinet.

Here are some out-of-tune notes noticed on the E flat clarinet. Measurements were done on instruments made by Yamaha, Buffet-Crampon and Selmer.

E1	-20
F	-15
F#	-20
G1	-15
E2	-10
A2	+10
A#2	+10
C#2	-5
G3	-20
G#3	-25
A3	-20
C#3	+10
D#3	-10
E4	-20
F4	-25
F#4	-30

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The Bassoon

The name bassoon appears first in 1706 in Edward Phillips' *New World of Words*, a dictionary which was published in six editions between 1658 and 1706. Until then, and indeed until 1750, the instrument was known as the curtall or the double curtall. The bassoon consists of a wooden tube of a combined cylindrical-conical bore about 2,5 m in length. For convenience this is doubled back in U-shape and divided into sections:

1. The bell-joint.
2. The long-joint or the bass-joint.
3. The butt, boot or double-joint.
4. The wing or the tenor-joint.
5. The crook, a metal S-shaped tube to which the reed is fixed.

The double-joint is a peculiar feature of the bassoon, as it consists of two channels - a narrow bore enlarging downwards, turning at the foot and increasing as it continues to the top of the parallel bore. The upper end of each bore is provided with a metal-lined socket into which the long-joint and the tenor-joint are inserted.

The word bassoon is derived from Latin *bassus*; French *bas*; Italian *basso*; Spanish *bajo*, in the sense of deep-sounding. Mersenne (see notes on flute, p. 4), in 1636, was the first to use the word *basson* (the French spelling) as an equivalent for *fagotto*. The earliest reference to a bassoonist in France came around 1602, when Michael Tornatoris was appointed serpentist and bassoonist to the Church of Notre-Dame des Domes in Avignon (as stated in the *Musical Times*, 1 July 1927)¹. In Italy, the earliest record of the word *fagotto* is in 1546 at the Accademia Filarmonica of Verona. It should be mentioned that by 1685, the inventory of the Academy includes *fagotti* (which means more than one *fagott*). In Spain, the earliest reference to *Bajo* is found in Madrid in the list of the Royal Band which in 1588 included: a bassoonist, Melchior de Camargo, mentioned again in 1633 and 1637. In Germany, the operas and ballets of Lully exerted considerably influence upon the German music, and this influence extended also to the name of the instruments: Flöte became Flûte Traversière, Schalmey became Hautboi, and Fagott became Basson. The first bassoon was made in Dresden around 1696, and the terminology lasted over a century, until 1800, when the German *fagott* was restored.

The origins of the bassoon are still shrouded in mystery. Even the country of its origin is uncertain, as very few early specimens survive, and it is not possible to be sure where and when they were first made.

1. Langwill, Lyndesey. *The Bassoon and the Contrabassoon*, *Musical Times*, 1927, p. 6.

It is probable that the device of two parallel channels connected in U-shape can be attributed to Canon Afranio of Ferrara (1480-c.1565) who, before 1521, was experimenting with an instrument he named Phagotum. There is an illustrated description of that instrument by Teseo Albonesi, a nephew of Afranio, in *Introductio in Chaldaicam Linguam*, printed in Pavia in 1539. The Italian name for the bassoon has been fagotto since the late sixteenth-century, and there is some confusion whether the bassoon is descended from the Phagotum. Every reference book for centuries has credited Afranio with the invention of the bassoon, making a comparison between the features of the two instruments. The fact is that the phagotum, with its bellows-blown pair of two cylindrical bores (the bassoon is a mouth-blown single U-tube of conical bore) sounded by a single metal reed, against the double cane reed of the bassoon, it was rather a type of bagpipe.

In general, two versions of the instrument may be distinguished: the earlier, until about 1700, was essentially in one piece and was called a dulcian, and then later a bassoon proper in three or four joints. Derivatives of four different names have been in use since early times: fagott, curtal, dulcian and bassoon. The first term originated in fourteenth century France as fagot, meaning a bundle of sticks fagotés (tied) together, a fagot. Chorist fagott was an early name for the dulcian, and the name fagott was applied in the seventeenth century to the bass pommer as well in spite of the fact that neither resembled a bundle of sticks.

In the sixteenth century there must have been need for a deep instrument to form a bass line to the wind band that would surpass the trombone in agility, the bass recorder in loudness and the bass pommer in ease of handling. The dulcian had all the required elements: the double reed of the shawm, the curved crook of the bass recorder and bass shawm, and the double-back on itself of the bore of the phagotum. When and where the dulcian originated is unknown. The first mention of the dulcian in a reference work is in Lodovico Zacconi's (1555-1627) *Prattica di Musica*, published in Venice in 1592, where he wrote that the Fagotto chorista had a range of two octaves, less a tone, from C to B₂. The name shows the use of the instrument supporting the voice in choral music. It consisted of a single shaft of wood (maple or fruit) oval in section, nearly a meter tall, drilled with two bores connected at the bottom so as to form one continuous, conical tube. At the top, a curved brass crook was inserted into the narrow end of the bore, and the other end was slightly extended to form a flared bell. The thickness of the wall enabled the finger-holes to be drilled obliquely to accommodate the span of the fingers.

There were eight finger-holes and two open keys. Six fingers gave G, and by adding the keys and using the thumb, one could play the notes down to C. The basic scale overblew the octave, giving a range to g. Over fifty dulcians can be seen in museums at Vienna, Berlin, Brussels, Linz, Augsburg, Frankfurt, Nürnberg, Salzburg, Leipzig, Hamburg, Prague and Paris.

On its introduction to England, the early bassoon or dulcian was known as the curtall. The word first appeared in an inventory of Sir Thomas Kytson of Hengrave, Suffolk, in December 1574.¹ In 1575 a double curtall was included in the Waits Band of Exeter (the Waits were musicians paid by the City). In 1597, it is also found in the accounts of the Corporation of the City of London. The first description of the curtall dates from about 1688, the instrument belonging to Randle Holme, who died in 1707. Called a double courtal, this instrument is preserved in the British Museum. It is double the size of a single curtall, descending eight notes deeper. The instrument is huge, as if two pipes are fixed into one thick pipe. It has a brass crook in form of an S, six holes on the outside and three brass keys. This description of the double curtall provides evidence that the curtall, in its evolution from the one-piece dulcian during the seventeenth century, acquired a separate bell-joint, a bass-joint, a wing-joint and an extra key. The three keys on the double curtall are D and F of the dulcian, and contra B flat. Holme overlooked the two thumb-holes on the back of the curtall. At Coventry, in 1678, the Common Council appointed four Town Waits who were to play "two trebles, one tenor and one double curtall".²

The military bands, which were coming into existence, adopted the curtall, and in 1721, one hautboy and one curtall were added to the Grenadiers' Music. By 1783, the world curtall was dropped, and the band consisted of four clarinets, two horns, one trumpet and two bassoons. The confusion regarding the two names, curtall and bassoon, lasted over two centuries. James Grassineau (d. Bedford, 1767), in his *Musical Dictionary* published in London in 1740, writes: "Double curtall - a musical wind instrument like the bassoon, which plays the bass of the Hautboy". John Hayle, in his *Dictionary* of 1770 completes the confusion: "Fagottino - a single curtall, something like a small bassoon; Fagotto - the Double curtall or in reality, a double bassoon". Even Jeffrey Pulver, in his *Dictionary of Old English Music and Musical Instruments* (London, 1923) states:

1. Gage, J. *History and Antiquities of Hengrave in Suffolk*. (London, 1822), p.204

2. Sharp, T. *Dissertation on Pageants at Coventry*. (Coventry, 1825), p. 210

"there can be no doubt that the curtall was for some time used side by side with the bassoon, which was soon to displace it". The fact is that the curtall, was the name for the bassoon during its evolution from the sixteenth to the eighteenth centuries, after which the French "basson" was adopted and anglicised.

In the period when the dulcian or two-keyed fagotto was still in use, Michael Praetorius (1571-1621), wrote his monumental works *De Organographia* (1619) and *Theatrum Instrumentorum* or *Sciagraphia* (1620). Chapter XI of *De Organographia* is dedicated to the description of Fagotten-Dolcians, where he states that C is the lowest note of the *Chorist-Fagott* and F of the *Dopple-Fagott*. The *dopple-fagott* is of two kinds; the first is pitched to obtain a low F and is called *quint-fagott*; the other one is a *quart-fagott* and can go down to G. The latter can be used in natural keys, the former in flat keys. In his *Theatrum Instrumentorum*, Praetorius also describes a complete consort of fagotten, consisting of instruments of different sizes; the *Discant-fagott*, keyless (compass g-c2), *Fagott Piccolo*, two keys (compass G-g1), *Chorist-fagott*, two keys (compass C-g1), *Quart-fagott*, two keys, (compass G-a1), *Quint-fagott*, two keys, (compass F-g) and *Alt-fagott*, keyless (compass d-?). Praetorius also reported a project by Hans Schreiber of Berlin, to make a *Fagot-contra*, one octave lower than the *Chorist-fagott*.

Following Praetorius' work of 1619-1620, there is the comprehensive treatise of Marin Mersenne (1588-1648), *Harmonie Universelle*, published in Paris in 1636. In book five, Mersenne dealt with the wind instruments in twenty-five chapters. Chapter XXXII is dedicated to the description of the bassoons and fagots: "They are in two parts, to enable them to be carried and handled more conveniently. They are called fagots, as they resemble two pieces of wood, which are attached (*fagotés*) together¹. Mersenne's first fagot drawing (Plate 7) shows a crook fixed to carry the stream of air into the tube. It has three keys and eleven holes. One key closes the seventh hole and is unprotected, while the other two keys, closing the eighth and tenth keys respectively, are protected by cover-plates. One can also notice the shoe, of brass or other metal, which binds together the two branches of that instrument. The bore-ends are closed with two plugs which on the one hand prevent leakage and on the other ensure continuity of the air of the two tubes, so that the air entering through the reed can escape only by the twelfth hole and by the bell when all eleven holes are closed.

1. Grove, Sir George. *Dictionary of Music and Musicians*. Bassoon.

It is not possible to state when in the seventeenth century the one piece, two-keyed dulcian gave place to the three-keyed bassoon. The change required a separation of the long joint and tenor joint connected through the butt, and the addition of the bell. That addition lengthened the bore and enabled the player to produce the B flat, to this day the lowest note on the bassoon.

The earliest source of a new model bassoon in four joints is in the Art Museum in Aachen, Germany. There is a half-portrait, called "The Fagott Player" by Harmen Hals (1611-1669), son of the famous painter Frans Hals. This painting shows that the bassoon had developed considerably since the drawings of Praetorius and Mersenne. The instrument has turned mouldings on the upper joints that served both as decoration and as mounts for the keys. The wing joint has the characteristic thickening of the wall to enable the holes to be drilled obliquely. The bell has a bulb-like cavity at the end and its extra lengths enables the range to descend to the low B flat with the add of an extra key.

Perhaps the most conclusive evidence is that of a German woodwind maker, possibly Denner (see clarinet, p. 46), on an engraving of 1698 by Johann Christoff Weigel of Nürnberg (1661-1726). The engraving shows a bassoon maker at work boring the finger-holes of a dulcian, while on the floor lies a second dulcian. What is important is that leaning against the bench is a three-keyed bassoon of transitional form. It is important to mention that as long as the bassoon had only three keys (two for the thumbs and one for L or R4) it could be played on the left side, as in Weigel's drawing, or on the right side as it is today.

The addition of the fourth key, the G# key, stabilised the manner of holding the bassoon, as the G# key lies beside the F key and was played with the same finger but could not be reached if the hands were reversed. The four-keyed bassoon was first shown on the trade card of Coenraad Rijkel, an Amsterdam maker of about 1705 (Rijkel was born in Amsterdam in 1667). This model was to remain the standard instrument for the rest of the eighteenth century. The Baroque moulding on the upper joint disappeared, the keys being mounted instead of being in saddles. The four-keyed bassoon (the keys were F, D, B flat and G#) was the instrument for which Mozart wrote his famous bassoon concerto in 1774. There were numerous references about the four-keyed bassoon, but the most interesting one was in *Musicus Autodidacticus*, published by J.P. Eisel in 1738 in Germany. Eisel describes the four-keyed instrument, with a compass B flat-e1, and also showed a fingering chart, where for the first time the G# key could be seen.

The interesting fact is that it has been stated that the fourth key, the G# key, was added in 1751, but as mentioned above, Eisel recorded its existence in 1738. There are two surviving dated bassoons with the G# key: a bassoon by Stanesby Junior of 1747 and one which bears the name of the owner "G. de Bruijn", 1730, Brussels.

A very rare tutor, *Principe de Basson*, by Charles Abrahame (1764-1805), a Paris clarinetist at the Opera who also wrote pieces for clarinet, includes a fingering-chart showing a fifth key, the E flat key, operated by the left thumb on the long joint. The date of Abrahame's tutor was probably 1780-1800. The compass shown is for B flat to a1. Another tutor is the famous *Méthode de la Flûte Traversière, de la Flûte-à-bec et du Hautbois*, published by Hotteterre in Paris in 1707. Reissued by Antoine Bailleux, merchant of music in Paris, circa 1765, it also had finger-charts for clarinet and bassoon. The scale is for a five-keyed bassoon, with a compass from B flat to a1. The five notes were: B flat, D, E flat, F and G#.

The addition of the fifth and sixth keys (E flat and F#) happened almost at the same time. The E flat key was the earlier of the two and was operated by the left thumb on the French and English bassoons and by the left 4 on the German bassoon. There is a rare Dutch dictionary, *Muzijkaal Kunst*, published in Amsterdam in 1795 by J. Verschuere Reynvaan, showing fingering-charts for bassoons with four keys (compass B flat - c2) and with six keys (compass B flat- g1 or c2). The keys were B flat, d, E flat, F, G# and a harmonic key opened for fl upwards. The text also contains a very early reference to a crook key, for reaching the high g1.

The seventh key, a wing-key operated by the thumb and helping the production of a1 (as a twelfth of d in the fundamental), b flat1 and b natural is shown in E. Ozi's *Méthode de basson* of 1803. In his *Musikalishes Lexikone*, published in Frankfurt in 1802, H.C. Koch describes a seven-keyed bassoon (keys of B flat, D, E flat, F, G#, a1 and c2). The compass was B flat to b flat1. Beside the normal bassoon there were also the quartfagott, a fourth lower and the contrafagott, an octave lower.

The next important reference about an eight-keyed bassoon appeared in *The Cyclopaedia or Universal Dictionary of the Arts*, by the Rev. Abraham Rees (1743-1825) published in London in thirty-nine volumes between 1810-1824. The Plates for volume three include a fingering chart for an eight-keyed bassoon with an excellent engraving of the instrument. Its compass was from B flat to b flat1. The engraving is dated 1807 but the Plates were published in 1820.

An important contribution on some technical aspects of the bassoon belongs to Carl Bärmann (1782-1842), first bassoonist in the Royal Prussian Orchestra. In 1820 he wrote a valuable article, which can be helpful even by today's standards, entitled *Concerning the nature and peculiarities of the Bassoon and its use as a solo and orchestral instrument*. English bassoons of 1800 had eight keys, the usual six keys and the two wing keys. In the early nineteenth century, bassoons were made in Germany by K. A. Grenser (1720-1807), his nephew and successor J. H. Grenser (1764-1813), and by J. F. Grundmann (1727-1800) all of Dresden. In France the best bassoons were made by Savary père (active 1775-1827) and his son J. N. Savary fils (1786-1853). In England, the best makers of that time were Milhouse, Cahusac and Bilton.

Though the Dresden bassoons excelled in their beautiful tone, they were mainly used for accompaniment and in the keys of F, B flat, C, G major, and G and C minor. When technique required the keys of A or E major and solos were demanded, the inequality of the notes became apparent. Although keys were added to provide a remedy, the problem was not solved because the notes produced with the help of extra keys sounded clear and even, while the other notes sounded muffled and unclear. It now became obvious that the body of the bassoon was faulty and required changes.

The radical improvement of the bassoon was achieved by Carl Almenröder (1786-1839), a bandmaster, bassoon player and later Chamber Musician at the Court of the Duke of Nassau. He had expert guidance from Gotfried Weber (1779-1839), famous musical theoretician and acoustician, who also founded *Caecilia*, a musical magazine. After years of experimentation in Schott's factory in Mainz, Almenröder published in 1820 his *Traité* on the improvement of the bassoon. In his *Traité* he describes in three parts his fifteen-keyed bassoon. In part one he describes the alterations in the construction of the bassoon; Almenröder gives Grenser the credit of inventing the key for c# and c#1, which he placed on the wing, to be operated by L4. This key which also gives d# and d#1 could fulfil its function, but the position given to the hole by Grenser had the defect of allowing water to enter and form bubbles, thus blocking the hole. Almenröder remedied this problem by transferring the hole to the other side of the wing, where it could be operated by the LT (left thumb), thus avoiding any water entering. Noticing that the notes produced by this key lacked clearness, Almenröder reduced the length of the butt and correspondingly lengthened the bass joint and wing.

By these means he was able to make the key-hole at a suitable place and by enlarging it remedied the lack of clarity. Next he dealt with the A hole for R3 on the butt. Until then this hole had to be made narrower so it could be fingered easily when R1, 2 and 3 covered the hole on the butt. Because the intonation and the sound suffered in consequence, Almenröder placed the hole lower between the rods of F and G# keys, changing it into two holes, one of which opened into the narrow bore, while the other into the wide bore, the later hole serving also as a "vent" hole. The two holes were operated by an open key, which could be closed by R3 (this key is sometimes called the twin G-key). By this invention Almenröder obtained a "pure" octave A to a, and a good equality of tone from A to a, an advantage almost absent on ordinary bassoons before him. Then he added on the butt the B flat key, operated by R3, an essential key for trills with A and B flat. On the back of the butt he added, beside the F# key, an extra key which, when opened simultaneously with the F# key produced a pure G#, thus enabling the notes F#/G# to be slurred, an advantage impossible before.

Almenröder also extended the compass down to C# by adding a special key to the bass joint, a key operated by L4 near D#. To obtain the B natural missing on the bassoon at that time, he transferred the B flat key to the bell joint, where the hole had a double function. It served as a "vent", and it also improved and strengthened the low notes from C to F. Finally, to facilitate the closure of the B flat, B natural and D keys with the intervening newly-made C hole, operated all by the left thumb, Almenröder added a short key (open-standing) with a touch-piece, which enabled the left thumb to work more easily and allowing the slurring of these low notes as well as the closure of two or more of them simultaneously. This "short" key exists to this day on all modern German and French bassoons as well. In part two of his *Traité*, Almenröder gives special fingerings to the most difficult passages on the bassoon, and in part three he describes special fingerings for trills impossible before the F#, middle c# and B flat keys were added. The recommended fingerings are for a fourteen-keyed bassoon with a compass from B flat to g2.

From that point on, the history of the German bassoon is associated with the world famous firm of Heckel. In 1829, Johann Adam Heckel (1812-1877) was employed in Mainz at the firm of B. Schott, where he met Almenröder. Together they opened a business at Biebrich in March 1831. Until Almenröder's death in 1843 they made bassoons for Schott, and on the preserved steel-stamp one can read: "B. Schott fils, Mayence".

The Heckel-Almenräder bassoon was developed, and an illustration and description of a sixteen-keyed bassoon of 1825-1828 appears in Adam Carse's *Musical Wind Instruments*¹.

Before Almenräder died in 1843, the middle B flat hole was moved to the back of the butt, and the key was provided with dual control by the right thumb and by a lever passing through the butt, by R3. It was also necessary to alter the position of the right thumb-hole and to enlarge it. To enable the hole to be covered, an open key, the so-called E-plate for the right thumb, was added. Before the middle of the century Heckel changed the keys mounted on saddles with cupped keys mounted on pillars. The adoption of the rod-axles (the invention of Boehm) also improved greatly the efficiency of the key mechanism.

On the death of John Adam Heckel in 1877, his son and successor Wilhelm (1865-1909) undertook a radical change to the bore of the bassoon. With the aid of a micrometer he regulated the course of the cone down to extremely precise measurements. After making the A hole, he changed the F and G holes farther downwards and widened the bore evenly to the bottom to suit the increased wind supply. He also changed the twin G-key for R3, moving the hole lower to a more rational position, and fitted a single large key. The reasons for all these changes were justified in the sense that it was easy to catch water on the position of the A hole made by Almenräder; the twin key was difficult to pad and ensure a tight cover; a tube fitted into the interior of the bore to prevent water running out of the hole interfered with the cleaning of the bore and the tone was also affected. In 1870 Heckel introduced the F#/G# shake-key, and in 1880 the C#/D# key. In 1901 Heckel brought out his through-bored G-key for the R3, and in 1902 the self-operated ring mechanism for the high g was successfully introduced.

Over the years numerous experiments were made to close the vent-hole in the crook, but only in 1905 did Heckel introduce the present mechanism. Operated by the RT, it leads from the low E-plate on the butt and over the wing-joint to the small vent-hole in the crook. This mechanism is nowadays made with some extra devices, which are operated by the right or left thumb.

A departure from Heckel's opened key for B natural on the bell is found on instruments made by the German woodwind maker Carl August Schaufler (1792-1877) of Stuttgart, who made the so-called Neukirchner's Model around 1845.

1. Adam Carse - *Musical Wind Instruments*. (London, 1939). Plates XIII and XIV.

The name comes from Wenzel Neukirchner (1805-1889), a Bohemian virtuoso who played first bassoon in the Royal Orchestra at Stuttgart about 1831, where he met Schaufler.

A closed key as on French bassoons instead of an open key covered the low B natural hole. Other improvements were:

1. The omission of the pin-hole in the crook, already tried in 1814 by Schaufler.
2. The U-channel at the butt instead of the twin plugs.
3. A broader bell.
4. Two more keys on the wing-joint.

Heckel understood the importance of having the wall of the bore as smooth and free from moisture as possible. That was why he insisted on oiling the bore from time to time. However, in 1889, Wilhelm Heckel patented the vulcanised rubber lining. It consists of a lining or sleeve for the bore of the wing and for the narrow bore of the butt, the parts most attacked by moisture.

On the death of Wilhelm Heckel in 1909, he was succeeded by his two sons Wilhelm Hermann Heckel (1879-1952) and August Heckel (1880-1914) who had been his assistants for fifteen years. Wilhelm H. Heckel's only child married Franz Groffy (who died in 1972), who firstly assisted his father-in-law, taking control in 1952. His son-in-law, Adolf W. Gebhard, and his daughter, Edith, have succeeded him.

The development of the bassoon in France has been recorded by Constant Pierre, a bassoon player who wrote two famous books: *Les Facteurs d'Instruments de Musique* (Paris, 1883), and *La Facture Instrumentale à L'Exposition de 1889* (Paris, 1890). According to Pierre, there were in Paris in 1752 only five makers of woodwind instruments: Charles Bizey (active c.1716-1752), Thomas Lot (active c.1740-1785) Paul Villars (active c. 1734-1749), Jacques Lusse (or Delusse), and Denis Vincent (active c.1728-1774). Specimens by Delusse, Bizey and Lot still survive. A one-octave bassoon or fagottino by Delusse (active c. 1736-1770) is shown in Lavignac's *Encyclopaedia*.¹ There are seven keys; B flat, D, E flat, F, F#, G# and a'. Delusse made also a "contrabasse de hautbois" which was announced in the *Almanach Musical* in 1781. Another surviving specimen is the four-keyed bassoon by Bizey in the Zimmermann Collection in Paris.

1. Lavignac, Laurencie. *Encyclopedie de la Musique* (Paris, 1927).

Two-octave bassoons from about 1780 by Martin Lot have survived: one fagottino has three keys and the other has five keys. The first one can be seen in the Donaldson Collection, Royal College of Music, London and the other one in the Bate Collection, London.

In 1769, a new woodwind maker, Prudent Thierriot, better known as Prudent (active in Paris c. 1769-1830), started making oboes, clarinets and bassoons. A five-keyed bassoon marked *Prudent à Paris* can be seen in the Paris Conservatoire Museum. In the same museum as no. 1121, there is also a six-keyed Prudent bassoon with an interchangeable wing-joint.

Another noted Paris bassoon-maker was Dominique Porthaux, who was active in Paris from c.1782 until 1824. There are six bassoons surviving, some with five and some with seven keys. His bassoons have a narrow bore and are quite light. The keys are slightly flat and mounted in light saddles screwed into the wood. Porthaux also invented a wooden crook, replacing the metal one, an invention, which unfortunately did not last.

Michel Amlingue, from 1785 until 1826, supplied bassoons with five-eight keys for the French Guards and for the military bands formed after 1790. Winnen Père (1788-1834) is remembered partly because of his employment for Triébert (see p. 30), and partly through the work with his son Jean (1795-1867). Father and son invented the "Bassonore". This instrument has a wide bore and bell and thirteen keys, giving a compass of three octaves and a third (B flat-d"). According to Fétis¹, the bassonore had a tone almost four times as powerful as the bassoon. Jean Winnen, having perfected the bassonore, obtained a bronze medal for it at the Paris Exhibition in 1844. A beautiful seven-keyed bassoon by Winnen is in the G. Thibault Collection in Paris.

Other woodwind makers who contributed to the development of the French bassoon were Pezé, who made six keyed bassoons from 1800 to 1830 in Paris and Baumann (1790-1830), who advertised contrabassoons in Paris about 1825, but no specimen has survived. Two seven-keyed bassoons are recorded. An important contribution to the development of the French bassoons was represented by Savary père and Savary jeune (young). Savary père worked in Paris from 1788 to 1826. One specimen of his bassoon can be seen in Brussels, no. 3120; it is made of maple wood and has nine brass keys including two wing keys for a' and c'. Jean-Nicolas Savary (Savary jeune), born in 1786, devoted his life to the bassoon.

1. Fétis, F. G. French theorist, author of the *Biographie Universelle des Musiciens*. 2nd edit. (Paris, 1860-1865)

After obtaining first prize at the Paris Conservatoire, he was appointed solo bassoon at the Théâtre des Italiens and was in the position to notice all the imperfections of the instrument. After opening his workshop in 1823, he invented a tuning slide on the wing-joint controlled by a rack mechanism. He made bassoons from 1823 until 1852, and he died in 1853. Savary's bassoons were also very popular in England too where many of the principal players used them from one generation to the next, until the orchestral sharp pitch began to be lowered in 1895, followed by the military pitch in 1929.

Frédéric Guillaume Adler started his business in Paris a little before 1809. In 1827 he made a bassoon (with Almenröder's fifteen keys) for which he received a mention, and in 1834 added rollers to his fifteen-keyed bassoon. The rollers, invented by César Janssen in 1823, facilitate movement from one key to another making the technique easier. He also added a tuning-slide to the wing joint. Fétis remarked that Adler's bassoons were very skilfully made, but there were defects of intonation and unevenness of tone. In 1839 the report of the Paris Exhibition stated that Adler's bassoons were longer than normal, had a small bell, and two new keys were added to produce the high d" and e". He was awarded the bronze medal in 1844 for his contrabassoon, his bassoon, and for a bassoon with a metal bell with a more powerful tone.

Eugene Jancourt (1815-1900), famous player and teacher at the Paris Conservatoire, from 1875 until 1891, published his *Méthode de Basson* in 1847 and in 1876 *Étude de basson perfectionné*. In 1845, Jancourt together with Buffet-Crampon (the noted Paris woodwind instruments makers) made some modifications to the bassoon: they replaced the key saddles with key rods and pillars; they added a crook-key for L4 to close the pin-hole in the crook, which enabled the lower notes to be played much softer. Mention should be made that it existed formerly as a pin-hole in the crook, but there was no mechanism of closing it, and that made the low notes unsafe. A chart for a seventeen-keyed bassoon is included in Jancourt's *Méthode*; he also mentions Triébert's name, praising his contribution to the development of the bassoon.

Frédéric Triébert (see p. 30), also well-known for his work on the oboe, made a bassoon highly praised as having a very even tone and easy fingerings. Without radically changing the ordinary fingerings, Triébert improved three notes: middle a, which could be played without fear of "cracking" (on the old bassoon one had to add the right thumb); e' is produced more easily with L1 and by opening the G# key with R4; a flat' or g#' can be played with L2 and L3, and the f' can be taken with "all open", like f below.

Triébert also greatly improved the middle register. It had an extra high note e" produced by a key placed above L1 and when raised also opened the key for e flat". The slurs to g', which were difficult for the lower notes on the old bassoon, became easier to produce without any embouchure effort.

In 1850, Jancourt and Triébert moved the A hole (Almenräder had done it in Germany thirty years earlier) and fitted a plate for R3, giving the note steadiness. Triébert also altered the bore, making it wider, to give the lower notes fullness and replaced the base-plug with a metal tube. He also altered the bore of the crook to make the sound even in all registers, from the low to the high notes.

In a later chart, about 1875, there are nineteen keys and a ring with a small vent-key B natural operated by R2. At a later stage he added a half-hole plate for L1, held down by a ring for L2. The rings were later abandoned and when Jancourt became professor at the Paris Conservatoire in 1875, he established the standardised Conservatoire Model with twenty-two keys. These keys include two shake-keys on the butt, one for g'/a' and the other for low F#/G#, the latter being considered for a century to be impossible on the bassoon. Rollers were also fitted to the G and B flat keys on the butt, as had earlier been done to the F and G# keys (Jancourt's *Méthode* of 1847 shows rollers on F and G# keys for R4). L. Letellier, professor at the Paris Conservatoire 1922-1933, designed a new crook, making it easier to play in all register with greater accuracy.

Finally, mention should be made of J. Francois Simiot of Lyons. He started his business c.1803, and before 1808 he added a tuning-slide to the wing-joint and a wing-key to help the production of a'. He also added keys for LT for low B natural and C#. In 1817 he replaced the butt-plug of cork by a metal U-tube and gave the bell an oval shape in order to increase the volume of the low notes. For his contribution to the development of the bassoon, the jury at the Paris Exhibition of 1823 awarded him a silver medal. Simiot continued his business until 1835. Although bassoons by Simiot are very rare, a beautiful instrument made by him can be seen in the Musée des Arts et Métiers, Paris. The instrument has nine keys, including two harmonic keys for LT.

Efforts to improve the bassoon were also made in Belgium, where in about 1820 Charles Joseph Sax (1791-1865) was the first to design a bassoon with covered holes. After further experiments, in about 1840, he constructed a metal bassoon.

It was that idea which led Adolphe Sax, the inventor of the saxophone, to produce in Paris in 1851 a twenty-three-keyed metal bassoon. By using finger-plates, he was able to place the holes at their correct interval, as Boehm stated in his mathematical principles. Actually after Boehm heard the instrument demonstrated by Baumann, a noted London player, at the Great Exhibition of 1851 in London, he passed through Paris and visited Sax to compliment him for what he had achieved. Sax showed it again at the London Exhibition of 1862, but the instrument was not demonstrated and was never manufactured.

Mention should be made here to the Boehm's system bassoon; in 1850, Boehm reported that he had completed a bassoon tube with all holes placed accordingly to his acoustical principles, as applied to the flute and the oboe. The production of a new practical fingering system was a difficult task, and he entrusted Triébert to help him solve this problem. Triébert made an accurate instrument regarding intonation and fullness of tone but, the system of rods and rings was difficult to apply to the bassoon, as the long metal rods made a disturbing clicking sound. Triébert continued his effort to improve the system of rods, and his model was presented at the London Exhibition of 1862. The Triébert-Boehm bassoon had a faultless key mechanism; its tone was homogenous, but it had the disadvantage of differing too much from the ordinary bassoon with regard to timbre. Probably the high cost also mitigated against its adoption. Nevertheless Triébert was awarded the Prize Medal for it.

There are four such bassoons, which can be seen:

1. Stamped F. Triébert. Paris Conservatoire Museum No. 510.
2. Stamped Breveté. Triébert à Paris. Brussels Conservatoire Museum No. 3119.
3. Stamped A. Marzoli à Paris. Breveté. Boston Museum of Fine Arts. No. 151.
4. Stamped Marzoli à Paris. W. R. Waterhouse, London.

Two of the bassoons were stamped by Marzoli, who was a bassoon player at the Théâtre des Italiens, and worked for some time with Triébert. Apparently Marzoli played the Boehm-bassoon in the orchestra and also made very good bassoons and contrabassoons.

After Charles-Luis Triébert died, his brother Frédéric continued the family business and was awarded the Gold Medal at the Paris Exhibition of 1867. In 1872 he had patented some improvements to the oboe and bassoon, and the firm was taken over by the firm of Gautrot in 1881.

In Germany an attempt to produce a Boehm-system bassoon was made by Heinrich J. Haseneier (1835-1921), a bassoon maker in Koblenz, known better as the inventor of the contra-bassophon. A bit shorter than the Buffet bassoon, Haseneier's instrument has a wide bell. The butt is very short and the bass-joint and wing are unusually long. The pitch is almost a semitone above the modern pitch and there are twenty-one keys, including finger-plates for G, A, B (R3, 2 and 1), and c, d, e (L3, 2 and 1).

In England the efforts to make a Boehm bassoon are attributed to Tamplini. Giuseppe Tamplini (1817-1888) of Bologna, Italy, came to London in 1847 from the La Scala, Milan, and became first bassoon at Her Majesty's Theatre. Under Tamplini's guidance Cornelius Ward, an inventive craftsman and friend of Tamplini, made a bassoon with twenty-three covered holes. This instrument was presented at the Great Exhibition of 1851 in London and patented in 1853. Apparently in 1855 Tamplini took one of his bassoons to Paris and showed it to Triébert but, unfortunately, Boehm had already contacted Triébert who agreed to construct a bassoon according to his (Boehm's) principles.

In conclusion, the attempts to improve the fingerings and intonation of the bassoon by applying Boehm's rational acoustical principles did not materialise. This failure can be attributed to the impossibility of applying these principles while retaining the characteristic tone quality of the bassoon and also to the traditional conservatism of manufacturers, players and teachers, a fact discussed by Tamplini in his work, *A Short description of the Boehm system and its application to the Bassoon*, published in Bologna, Italy in 1888.

Mention should also be made of another attempt to improve the bassoon by making it of metal. Lecômte & Cie of Paris constructed a bassoon of German silver, for which they obtained French and British patents (29 June and 31 October 1889 respectively). Pierre in his work *La Facture instrumentale*, claims that the bassoon had an increased sonority, but its timbre was now changed. The low notes were very good, the middle register was almost like that of a normal bassoon and from the beginning of the third octave up the notes had unfortunately a metallic quality, sounding more like a saxophone than a bassoon. A seven-keyed specimen of Lecômte's metal bassoon is in the Stearn Collection, Ann Arbor (No. 682). A Lecômte metal bassoon was shown at the Paris Exhibition of 1889, but afterwards no more was heard about this instrument.

The question is often asked as to why the German bassoon superseded the French type from about the 1930's everywhere except France, Spain and occasionally Italy. At present more and more French orchestras require the German-system bassoon. A professional comparison of the two types is given by Anthony Baines in his *Woodwind Instruments and their History* (London, 1967, pp. 341-342). He states that even though their fingerings differ, neither has a decisive advantage over the other. The good point in favour of Heckel (the German system) is that from the bottom to the top and from *piano* to *forte*, it has an even tone, especially useful in the orchestra. Against the German system the quality of tone of the French bassoon (Buffet) is more refined and vocal. However, it is much harder to control and the quality of the reed is crucial. One should add that the shape of the reed varies considerably. In some American orchestras there is a tendency to make the reed as little as fourteen millimeters across the tip and circular at the throat instead of slightly flattened as it is more usual. This procedure introduces a touch of vocal quality of the French bassoon, helping the instrument to blend very well with other woodwind instruments. The truth is, of course, that there are great players on both types of bassoons, and it depends on the music they play and the personal choice of the listener.

The bassoons most played today are those made by Heckel, Adler, Püchner, Schreiber, Fox, and for the French system, Buffet still holds supremacy.

Intonation on the Bassoon

Bassoon playing has a compass of over three and one half octaves. Some forty-two notes must be produced by using ten fingers. The bassoon is the only wind instrument that uses all ten fingers while playing and eighteen tone or semitone holes and three harmonic holes have to be controlled. Examining some acoustical particularities, one may observe that the lowest note, B flat, requires a tube-length of 2,59 m, the air passing through the bell, long joint, butt, wing and crook.

On the other hand, the holes outnumber the fingers to cover them, and keys are arranged in groups for easy handling by the fingers and the two thumbs. This also requires some compromises in the strict acoustical subdivision of the tube; the lateral sub-division of the tube-length actually requires the misplacement of the holes for F, G#, A, c, c#. To correct the intonation it is necessary to bore the holes obliquely with varied depth of penetration and diameter.

On the German bassoon, additional holes for resonance are bored in the wide bore of the butt to help the tone-holes in the narrow bore. A good example is the B flat and the A resonance holes. The ancient theory of employing the six-hole interval to suit the player's hands is not practical on the bassoon. This is the reason why very oblique tone-holes are bored, and the penetration of these is lengthened by thickening the tube at the points.

For the two thumbs and two little fingers, a combination of keys is provided to obtain uniform intonation and tone-colour throughout the entire compass. On the bassoon using the eighteen whole-tone and semitone holes, from the low B flat the middle f is reached. From that note up the octaves are reached by overblowing the fundamental scale. On the bassoon the overblowing is practicable only for f#, g, g#, a, b flat, c', c# and d, after which considerable differences in intonation can result. These differences can be corrected by auxiliary fingerings. From the notes d#" , e" and f" alternate fingerings should be used in conjunction with the a' and c' octave-key, as well by opening and closing the crook-hole, which is also an octave key.

Certain registers of the bassoon have some pitch tendency: as a general rule the pitch of the low register, from B flat to F is sharp on most instruments. The high register B flat to F is often played sharp by some young players who have not properly learnt the technique of opening the throat and using a relaxed embouchure. High F# is usually sharp. The G in the bass clef is always sharp on most bassoons. To correct this, many players add the low E natural or E flat keys. The third space E flat has a sharp tendency, which can also be improved by adding the low E flat key. Being a resonant key, the E flat key will also improve middle G, as stated above, high E in the bass clef and high F in the bass clef. To stabilise the basic forked E flat one should add the low E flat key in conjunction with the B flat key and the first or second finger of the right hand. The high C on the bass clef is often sharp and unstable. One should try adding the E flat key to the C, and also trying with this key half-way down. The middle C#/D flat in the bass clef which has a tendency to be rather sharp, can be stabilised by adding the low E flat key. Sometimes a new reed tends to produce a flat middle E or open F. To adjust this, a player could add the G key with the third finger of the right hand.

As a general rule, the notes that use the least fingers need the most lip for their control. An example would be the middle E and open F, naturally flat, which should be helped by the lower lip.

Special mention should be made of the crook, or bocal. The crook has been called the heart of the bassoon, because a good one can improve the middle range, the tone quality, the tuning, and it makes high notes easier to play. The instruments cannot be tuned by pulling the crook in and out, this practice will only make the registers out of tune. The crook should be aligned with the speaker-key hole directly behind the speaker-key pad. The lengths of the crook are from shortest to longest 00, 0, 1, 2, 3, and 4. The most common lengths used are No. 1 and No. 2. A bassoon, which is generally low in pitch, can be improved with a shorter crook, and one which is sharp, can be improved with a longer crook. One should remember that when playing too loud, the tendency of the pitch is to drop. There are also letter indications on the crooks.

Here is some information of crooks made by Heckel, Püchner and Fox.

Heckel: Lengths Available: 00, 0, 1, 2, 3, 4.

C - post-war indication.

CC - pre-war indication (normal for most bassoons).

CE - similar to C but with a smaller reed end.

B - a smaller bore than C.

BB - similar to B but with a smaller reed end.

D - a thinner wall crook than the standard C.

V - bores with variable wall thickness.

Püchner: Lengths Available: 0, 1, 2, 3, 4.

B - developed by L. Hugh Cooper in the 1960s.

C, D, CD - represent a chronological development in the crook. The CD has the attributes of both the C and the D. The Püchner B represents the same thing as Heckel pre-war CC.

Fox: Lengths Available: 0, 1, 2, 3, 4.

C - basic crook for students.

CV - similar to C but with thinner walls.

CVX - a large version of the C bore with variable wall thickness.

Professionals will differ in their opinion regarding the effectiveness of various crooks (or bocals). As a matter of interest Heckel himself lists some 800-900 different varieties of crooks.

Here is a chart with some out-of-tune notes noticed on the bassoon:

From B flat1 to F1		all notes have a sharp tendency.
E flat2	+	considered one of the worst notes on the bassoon.
F#2	+ 10	
G2	+ 10	
A#2	+ 10	
B2	+ 5 to 10	
C2		can be sharp and unstable.
E flat 3	-	can be very flat
F#3	+ 10	
G3	+ 10 to 15	
A flat3	+ 10 to 15	

The measurements were done on bassoons made by Heckel, Püchner, Hüller and Schreiber. Mention should be made that the Heckel bassoons have a sharper tendency than the other ones.

In their aim to further improve the intonation of their instruments, the firm of Püchner has recently announced that they are producing a new model, "Consonant", the tone holes of which are made at the acoustically right position, greatly improving the intonation of the bassoon.

The Contrabassoon

The first remarks about an instrument lower than the bassoon belong to Ludovico Zacconi¹. In his work *Praticca di musica* (Bologna, 1592), he gave the compass of an instrument, from the C in the bass clef to the B above the staff. He named the instrument Fagotto Chorista, referring to the Dopppe Fagotto, a fourth lower in G, or a fifth lower in F. The next description of a bassoon lower in pitch can be found in Praetorius's *De Organographia*, 1619 (see p.3). Both instruments were two-keyed dulzians: Quint fagott (F to e flat) and Quart fagott (G to f). Praetorius also made a reference to Hans Schreiber, chamber musician of the Electoral Court of Berlin, who made a fagot contra, one octave lower than the fagotto chorista, in about 1622. Two beautifully made dopple-fagotts, considered to be from late sixteenth century, of Italian origins, can be seen at Kunsthistorisches Museum in Vienna. Both instruments are held with the right hand above the left hand, contrary to the modern bassoon, and were probably pitched in G. Mention should be made of Bach, who used a dopple-fagott in Cantata No. 31, *Der Himmel lacht*. The range of the part is G-d, like the quart-fagot.

Early available evidence of a true double bassoon is a surviving instrument in Leipzig by Andreas Eichentop (c. 1670-1721), dated 1714. It resembles one of Denner's bassoons, only in a larger version, and it descends to the low C. Handel wrote a part for the contra-bassoon in his *Hymn for the Coronation* (of George the Second) in 1727. That contra, was made in the same year by the famous London maker Thomas Stanesby. The only surviving English contrabassoon was made by Stanesby Junior (1692-1754), and is preserved in the National Museum of Ireland, Dublin. This instrument descends to B flat, and is built like a large bassoon with four brass keys in saddles, giving B flat, D, F and G#. The bell has a bulbous shape expanding slightly at the top, and a very long brass crook. The finger-holes are smaller than acoustically required and, although they are bore obliquely, they are too far apart to be comfortable when playing. Handel also employed the contrabassoon in the *Fireworks Music* (1749) and in *L'Allegro* (1740). After that, the only English attempt to construct a contrabassoon in a normal bassoon shape was that of J. Samme of London, about 1855. The eight-keyed quart bassoon in low G is now preserved in the Donaldson Collection in the Royal College of Music, London.

1. Zacconi, Ludovico (1555-1627). Italian theorist.

Towards the end of the eighteenth century Double-bassoons (or Kontrafagotte, as the Germans called them), were included in German and Austrian military bands, and also used occasionally in the orchestra. Mozart, Haydn, Beethoven and Schubert used it in their scores.

During the nineteenth century experiments were made by different makers to construct a satisfactory double bassoon with a more powerful contrabass register for the military bands. Wrongly thinking that wooden contras had a weak tone, some makers tried using metal. Johann Stehle, a famous Viennese instrument maker (active from 1840 until 1855) made a metal contrabassoon, which he exhibited in 1839 (however, Pierre states in his *La Facture*, that the year was 1855). The holes were all covered by fifteen keys, with a compass of two octaves. Apparently, it was technically quite difficult to play, but it had a very powerful tone according to an article written in 1845 by W. Wieprecht in No. 43 of the *Berliner Musikzeitung*. In order to simplify the difficult technique of Stehle's contra, Carl Wilhelm Moritz (1811-1855), a famous instrument maker in Berlin, at the end of 1845 invented the Claviatur-Contrafagott, which had a keyboard like that of a piano-accordion. Fifteen keys were operated by the finger-board. The tube of the instrument had the same proportions as those of Stehle's, with a conical bore, a bassoon reed and a slide key, which assisted in producing the upper octave. There is a drawing in *Soldatenfreund*, from about 1860, of a bandsman of the "Second Garderegiment of Foot" carrying a claviatur-contrafagott, but unfortunately no example of this instrument survived.

A subsequent model was a brass contrafagott, invented in 1839 by Schollnast and Son of Pressburg (now Bratislava, Slovakia), and named Tritonicon. It was a very long instrument folded on itself five times, with fifteen large keys, only the first being open. This arrangement resembled the fingerings of a piano, and had a compass of sixteen notes from D to F. According to C. Sachs in the *Real-Lexicon* of 1913, the preference of simpler fingerings had the disadvantages of smaller tone-holes and poor intonation. A different version of a Tritonicon was made by Cervený (1819-1896), a maker from Königgratz in Bohemia. He produced in 1856 a fourteen-keyed tritonicon in E flat. Later, he made a tritonicon in B flat, a fourth lower than his 1856 model, and presented it twice at the Paris Exhibition, in 1867 and in 1889. It had a compass of two octaves, a powerful and vibrant tone, but little resembled to the tone of a true contrabassoon. A version by Mahillon¹, the famous Brussels maker, invented in 1868 was called contrabasse à anche, contra with a reed.

1. Mahillon, Charles (1813-1887). Belgian wind instruments maker.

It had its lowest note D,, instead of B flat,, but in all other respects was identical with Cervený's contra. It had seventeen keys, from which two were octave keys, and there were all closed keys, except the first one. The first four notes (D to F) were not overblown, but the others from F# to C were overblown by using one octave key. From C# to f the notes were overblown by using the other octave key. Both instruments, Mahillon's and Cervený's, were not true contrabassoons, as they did not produce the notes of the bassoon one octave lower with the bassoon's fingering. Later, similar instruments were made for their use in the military bands in France and Italy. Mention should be made of the deepest of all contras made in 1873 by Cervený and named Subcontrafagott. That instrument had fourteen keys, was in B flat and sounded one octave below the contrabassoon. Its compass was from B flat,, to B flat. It is difficult to imagine how such a huge instrument could be manipulated, and there is no surviving specimen of such subcontrafagotts.

After numerous experiments with metal, a new solution to the woodwind makers seemed to be the widening of the bore of the wooden contras. In 1874 H. J. Haseneier (1835-1921) of Koblenz, Germany, designed a new type of contrafagott, which he called the *Contrabassophon*. That instrument had a bore, which flared from 6 cm to over 10 cm, was not taller than the bassoon and had almost the same fingerings. It was considered a success at the time and immediately copied very closely by several makers.

In France, in about 1850 F. Ttriébert (see p.30) and A. Marzoli (a woodwind instruments maker active c. 1850) of Paris made a contra of bassoon shape of almost 2,5 m tall, which was used by the Société des Concerts du Conservatoire until 1863. P. Gumas et Cie, the Paris woodwind makers who traded until 1885, made a similar contra of wood with fifteen keys and covered holes, descending to contra C. Both of these instruments had the same disadvantage of being much too tall and very difficult to manipulate. At the same time, at the Paris Exhibition of 1889, Martin Thibouville¹ presented his first attempt to improve the contrabassoon. By coiling the tube in four parallel lengths, he reduced its height considerably and made the instrument much lighter. All holes were covered, and there were nineteen keys and six plates arranged in such a way as to retain the characteristics of the French system. In 1885, Evette and Schaeffer took over the business and trademark of Buffet-Crampon & Cie (see p. 50), and made a similar brass contra, corresponding in height and fingering to the bassoon.

1. Thibouville. French family of instruments makers. Martin Thibouville, in 1820 founded a woodwind instrument factory in La Couture, and before 1848 he opened a Paris shop.

The progress made by Heckel in Germany with his contra, led Evette and Schaeffer to make a new contra of wood, very similar to the German contra, except that the French fingering was retained. The new instrument was heard for the first time in 1906 at the performance of Richard Strauss' *Salomé* in Paris. Strauss' contrabassoon solo is quite difficult even by today's standards.

The modern French contrabassoon, like the German one, has a wooden bell-rim, which is used when the lowest note required is contra C, and an inverted metal bell, which can be put on when sub-contra B flat is required. In 1876, J. A. Heckel (1812-1877) with the help of his son W. Heckel (1856-1909), started transforming the contrabassoon, which until that time had a bassoon shape and descended only to contra C. Heckel divided the tube into three parallel tubes, altered the shape of the crook, and arranged the keys in such a way that the instrument was played left-handed: it was held at the left side of the player, the left hand being the lower one, contrary to today's practice, left hand above the right one. The fingers of both hands had the same movements as on a regular bassoon. This type of instrument descended to contra C and was termed "System Stritter". Friedrich Stritter worked in Heckel's workshop from 1871 until 1877, and when the old Heckel died, Stritter patented as his own Heckel's invention of the left-handed contra. The patent was recorded as No. 1131 in October 1877 in favour of Fr. Stritter of Biebrich, Germany.

Another attempt to improve the contra was made in 1886 by Adolf Brauenlich of Dresden. A detailed description of Professor Brauenlich's invention was published in the *Deutsche Musik Zeitung* in April 1886. Before Brauenlich's new model, complaints were made against the contras by Haseneier and even Heckel's. A common complaint against Haseneier was that his instruments were not suited to orchestral use, but to military bands only. Their bore was considered too large, making the low register imperfect in tune, and also very difficult to play it softly, as required often in an opera orchestra, where it overpowered the *piano* of all other woodwind instruments. The same complaints were made against Heckel's contras, as their bore was too narrow and the tone quite dull and weak in *forte* passages. Also the manner of holding the contra was quite annoying for someone accustomed to playing the bassoon. Apparently, Brauenlich's system was based on exact measurements and all the faults of other systems disappeared. The compass was from B flat, to c' or d', which had a great value in works like *The Creation* by Haydn and Beethoven's *Missa Solemnis*. Unfortunately no specimen of a Brauenlich contra exists in any collection.

At this point, mention should be made of the *Sarrusophone*. Adolphe Sax, who patented the saxophone and his group of seven sizes in 1846 in Paris, had suggested to Sarrus, bandmaster of the French 13th Regiment, a similar double-reed brass instruments. His idea was to replace the oboes and bassoons in military bands and the Paris maker P. L. Gautrot named it *sarrusophone* and took a French patent for it in 1856. Sarrus wanted six of this type of instruments but only the contrabass in E flat and another contrabass in C, made for orchestral use, have survived. The orchestral model has a compass of two octaves and a fifth from contra B flat. The instrument had a wide bore and large tone-holes, which give a powerful but unrefined tone, and if it brought loudness to the military bands, it has been used extremely rarely in the orchestra. An example would be Ravel's *Rapsodie espagnole* and Delius's *Danse Rhapsody*. In the USA the sarrusophone was first made by C. G. Conn at the request of the U. S. Government and has been used to some extent in military bands. Probably the fact that the fingering is very similar to that of the saxophone explains the American adoption and popularity.

To conclude the history of the contra, a final mention should be made again of the firm of Heckel of Biebrich, where from 1834 several contrabassoons were made until 1879 when the modern contra was perfected. The first contra was made in 1834 and had a normal bassoon shape. Its height was over 1,5m with an unusual long butt and a large crook. Some of these instruments were stamped "B. Schott", but they were all made by J. A. Heckel. The lowest note was contra D. In 1849 Heckel made an even taller bassoon-shape contra with the compass going down also to contra D. In 1876 Heckel made the left-handed contra, the so-called "Stritter System", to which reference has already been made above. About 1879, Heckel made the original type of the modern contrabassoon right-handed, with a vertical wooden bell. The instrument descended only to contra C. Heckel had continued to work on improving the bore, and he introduced two octave keys on the large crook to facilitate the fingering of the middle register. By that time, the contra had been enlarged so as to descend to contra B flat, and at Wagner's advice, Heckel constructed a contrabassoon with an extended bell, enabling the production of sub-contra A. For the downward extension from contra C, the bell is made either of a long upright shape, or with a large wooden bend terminating in an inverted metal bell. There are about ten variations in shape, and all bells to A,, or B flat,, are detachable and may be replaced by a wooden bell-rim for contra C. The large metal crook has a tuning-slide to regulate the pitch. All subsequent instruments have been based on Heckel's models, including Buffet's French version introduced in 1906.

Intonation on the Contrabassoon

As a general rule the low notes on the contrabassoon are quite flat, D1 and E1 being probably the lowest. The middle register is quite stable, except for F#2 which is the highest note on the contra. The very top notes have a tendency to flatness but they can be lipped up quite easily, the exception being G#4 which is very sharp. Apparently the pitch tendencies on the contra differ more from one instrument to another than on the bassoon. The following measurements have been done on contras made by Schreiber and Hüller.

Here is a chart with some out-of-tune notes on the contrabassoon:

B flat1	- 5
C1	-5 to 10
D1	-10 to 15
E1	-10
F#1	+5
G1	+5 to 10
G#1	+5 to 10
B flat2	+5 to 10
B2	-5 to 10
D2	+10 to 15
E2	+10
F2	-10
F#2	+30
G#2	+10
B flat3	-10
B3	-10
C3	can be unstable
C#3	-10 to 15
D3	-10
D#3	- and quite unstable
G3	+10 to 20

All notes above that are quite sharp and very unstable.

Factors influencing the intonation

Before analysing different types of tuning, it would be helpful to describe some basic laws of acoustics. The most important quality of a musical sound is its pitch or frequency, which is measured in Hertz (Hz). For example the standard tuning A is fixed at 440 Hz, or 440 cycles per second. When a low C for example is played on a piano, one can notice the following succession of notes: C1 in the bass clef (65.406 cycles per second), C2 in the bass clef (130.813), G1 in the bass clef (196.219), C3 in the treble clef (261.65), E1 (372.032), G2 (392.439), B flat1 (457.845 cycles per second), C4 (523.252), D1 (588.658), E2 (654.064), F#1 (719.4710), G#1 (784.878), A1 (850.274 cycles per second), B flat2 (915.641), B natural (981.097) and C5 (1046.504). The first note is called the fundamental and the first sixteen partials or overtones are the harmonics. A harmonic series can be constructed on every fundamental. One can observe that there are clear intervals in the harmonic series: the distance between the fundamental and the first harmonic gives the octave, between the third and the second gives the fifth, between the fourth and the third gives the fourth and so on. In the above example one can also notice that the second harmonic (130.813 cycles per second) vibrates twice as fast as the first one (65.406 cycles per second). The third harmonic vibrates three times faster than the fundamental and so on and by the time there are enough notes to create a chromatic scale, the twelve semitones are not equidistant. This brings us to the conclusion that the equal temperate scale is not perfect.

Here is a table of comparison showing the discrepancies among equal temperament (piano tuning), just intonation (harmonic series tuning), and Pythagorean tuning (string instruments tuning, based on perfect fourths and fifths).

	C	D	E	F	G	A	B	C
Equal Temperament	520	584	655	694	779	874	982	1040
Just Intonation	520	585	650	693	780	867	975	1040
Pythagorean Temperament	520	585	658	693	780	877	987	1040

One can notice the close agreement among the fourths and the fifths in each of the tuning systems. In equal temperament the octave is divided into twelve equal parts so each semitone is equidistant. This should allow a keyboard instrument to play in all twelve keys. Just intonation is playing in tune with the natural overtone series. Because the twelve semitones of the chromatic scale derive from the natural overtone series and they are not equal, the equal temperament evolves as a compromise.

In reality, the piano is out-of-tune: the pitch of the piano tends to be sharp to the natural overtone series in the high register, and flat in the low register. The octaves have to be stretched to eliminate beats. J. S. Bach was the first composer to use the tempered scale with octaves divided into equal semitones, sharp minor thirds and very sharp minor sevenths, making possible to play in tune in every key.

Many intonation imperfections result from the incompatibility of the equal tempered scale with the same pitches in the harmonic series. Playing in tune means to eliminate the beats that result from the difference of two notes played simultaneously. For example, A=440 played against A=442, creates beats at two cycles per second. The following chart shows how to alter the pitch from equal tempered scale to pure harmonic tuning, with all changes made to the upper tone (a semitone is measured on an electronic tuner in 100 cents, from 0 to 50 cents flat or sharp):

Major third	lower upper tone by about 14 cents.
Minor third	raise upper tone by almost 16 cents.
Perfect fourth	lower upper tone by 2 cents.
Perfect fifth	raise upper tone by 2 cents.
Major sixth	lower upper tone by almost 16 cents.
Minor sixth	raise upper tone by about 14 cents.
Minor seventh	lower upper tone by about 33 cents.

Wind players have to adhere to all three types of tuning: when playing with piano they have to adhere to the equal tempered scale, playing with strings requires Pythagorean temperament and playing in ensemble with non-fixed pitch instruments just intonation is used. The orchestral playing requires all three types of tuning. Woodwind players can eliminate beats in just intonation by adjusting their pitch to match the overtone series of the harmonic structure. As the harmonic structure is always changing, a woodwind player has to adjust the pitch all the time, which is much more difficult than playing with equal temperament. The most important phenomenon in just intonation is the presence of the resultant tones. Any two notes played simultaneously by two instruments will produce a third note. This third note represents the difference of the two frequencies being played, and is often heard as a faint pitch. For example, if one note is played at 600 cycles per second and the other at 400 cycles per second, the resultant tone will be 200 cycles per second. When two adjacent notes of overtone series are played simultaneously, the fundamental of that overtone series will be the resultant tone.

Alternate tones of an overtone series will produce a resultant tone one octave higher than the fundamental. If a C major chord is properly tuned there will be three resultants: C-E and E-G will each produce a fundamental, and C-G will produce a resultant tone one octave above the fundamental. To obtain the resultants (just a reminder that the pure major and minor thirds that result from tuning to the harmonic series differ from thirds in an equal tempered scale), the third of the triad (E) has to be played 14 cents lower than the equal tempered scale (see the chart on the previous page). The fifth (G) has also to be altered by 2 cents higher. This will create a more beautifully-tuned fundamental than in the equal tempered scale.

When playing in an ensemble it would be helpful to memorise the following intervals as they relate to equal temperament:

Perfect fifth	wider than equal temperament
Perfect fourth	narrower than equal temperament
Major third	narrower
Minor third	wider
Major sixth	narrower
Minor sixth	wider
Major second	wider
Minor second	narrower
Major seventh	wider
Minor seventh	narrower
Octave	the same or narrower

When a player is out of tune, beats are noticeable. When a player is slightly out of tune, the resultant is heard out of tune. By tuning the resultant, the player can make the chord in tune, blending with the harmonic structure. Unfortunately, there are situations when the resultants are non-chord notes, like in the minor chords. For example, in the A minor triad, A-E produces the resultant of A; C-E produces a resultant of C, but A-C produces a resultant of F, which is a non-chord note. A minor chord cannot really be tuned without beats, because of this resultant of major third, which beats against the minor one. This could be the reason why so many Renaissance pieces in minor keys ended on a Piccardy (major) third.

When playing solo with piano, woodwind players have to adjust to the equal temperament and check all the notes to avoid a direct clash.

When playing with the strings, woodwind players should remember that string players use sharp leading notes. In C major, for example, E and B would be played high, which creates beats on the tonic and dominant chords. One has also to remember to blend perfectly with the open strings (one must know all the open strings of each of the stringed instrument family), as obviously, they cannot be humoured during performance.

Another problem for intonation is caused by modulation. If a piece starts in a major key and modulates to its third, the third will be 14 cents lower than the equal temperament. Then, if it modulates again to its third, the third will be 28 cents flatter, and so on. The pitch level becomes too low for woodwind instruments to play. During a modulation, it is best to use the equal temperament for the tonic of the new key, and use just intonation on the new key.

The problem of intonation in the woodwind quartet (flute, oboe, clarinet and bassoon) results in the fact that every instrument behaves differently in extreme dynamics. The flute and oboe go sharp when playing forte, while the clarinet and bassoon have a strong tendency of going flat. There are also particular anomalies already described in the previous chapters of discrepancies within each instrument's register. A good example would be the flute's low register, with its tendency of being very low in pitch in soft passages, against the clarinet's strong tendency of being sharp in the low register when playing softly. A good musician should know all these tendencies to be able to play more in tune and to blend with the harmonic structure.

The atmospheric temperature influences the pitch of woodwind instruments considerably. As a general rule when the temperature rises, the pitch of woodwind instruments also rises. The same rule applies when the temperature drops; the pitch of woodwinds also drops. What really makes the problem worse is the fact that the pitch of the keyboard and of metal instruments rises when is cold, as the metal contracts, and the strings have a tendency of going flat after long playing.

During the author's twenty years experience in a symphony orchestra the most evident phenomenon is the permanent rise of the pitch during performance. Different countries have different pitch standards: in USA. the normal tuning is A=440; in Germany is almost A=445; in some East European countries and in South Africa A=442. If a concert starts at A=442, at the end of the concert the pitch is so high that sometimes reaches A=446.

The problem is that one can not lower the pitch very much by pulling out the head-joint of the flute, or the reed of the oboe, or the barrel of the clarinet, as this procedure disturbs the relation between the notes, and the instrument will be out-of tune with itself.

There are also endless examples when a good balance can influence the intonation. In a major chord, for example, if the flute plays the third of the chord one octave above other instruments, the best dynamic level is piano. That will help the flute to blend better, and avoid the note to stick out and sound out-of tune. The same example often applies to all the woodwinds as well.

If there is a secret to good intonation it is a very simple one: the player must keep the pitch. One has to remember that a perfectly in tune woodwind instrument does not exist and a player has to be extremely alert to the general pitch. It is very important for a player to know his/her instrument pitch tendencies to be able to adjust accordingly. It will be of a considerable help if one also knows the tendencies of the instruments with which he/she is playing. One has also to remember that tuning from the oboe's A means too little. It is called the "A" syndrome, because if the A is in tune it does not mean that every note is in tune.

Another problem noticed by the author is the tuning of a chord starting from the bottom (as normally should be done) with the bassoon. It has been already described how sharp are the low notes on the bassoon, and every added voice will be higher and higher, the top note eventually will sound flat if in tune. Care should be taken to keep the pitch down for the first note, and here the player should know all his out of tune notes.

The improvement of intonation is a never-ending battle and it helps to know every instrument's intonation particularities and to develop flexibility to adjust. An attitude of compromise will always help and one has to remember that no one has the last word. The intonation is a matter of listening all the time, adjusting all the time, and remembering that playing in an ensemble requires dedication and professionalism. All players have as common goal to render as beautifully and perfectly in tune as possible the music performed.

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