

# Full text of "The flute and flute-playing : in acoustical, technical, and artistic aspects"

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Theobald Boehm

Aged 3 4

At the time of the development of the conical bore, ring key, flute

THE FLUTE  
AND FLUTE- PLAYING

IN ACOUSTICAL, TECHNICAL, AND  
ARTISTIC ASPECTS

THEOBALD BOEHM

Royal Bavarian Court-Musician  
ORIGINALLY PUBLISHED IN GERMAN IN 1871

TRANSLATED AND ANNOTATED BY

DAYTON C. MILLER, D. Sc.

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PUBLISHED BY

DAYTON C. miller

Case School of Applied Science, Cleveland, Ohio

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Munich, August 6th, 1908

Dear Mr. Miller. —

/ wish to express my, and my sisters',  
great pleasure and satisfaction for your labor of  
love, which you have undertaken in the good  
intention to honor my grandfather. For this we  
can be only very thankful to you; and I believe  
I express the sentiment of the whole family of  
my grandfather in giving you our approval of  
the publishing of your translation of his book:  
\*'Die Flöte und das Flöten spie I. ^'

Yours very truly

Theobald Böhm.

{The above is an extract from a personal letter ; the original  
is written in English.]

#### TRANSLATOR'S INTRODUCTION

THEOBALD BOEHM, of Munich, — born in 1794,  
died in 1881, — a celebrated Royal Bavarian  
Court-Musician, and inventor of the modern  
flute, described his inventions in a treatise on "Die  
Flöte und das Flötenspiel" ; this work was read with  
great interest by the writer, and while upon a holiday  
some years ago, it was translated ; others having  
expressed a desire to read the work in English, its  
publication has been undertaken.

While much has been written about the Boehm

flute. Boehm's own writings seem not to have received the attention they deserve ; this is especially true of the work here presented; his earlier pamphlet, published in German in 1847, in French in 1848, and in English in 1882, is better known. In the introduction to "Die Flöte und das Flötenspiel," Boehm says : "My treatise, Ueber den Flöteibau und die neuesten Verbesserungen desselben (1847), seems to have had but little influence. There is need, therefore, of this work in which is given as complete a description as is possible of my flutes and instructions for handling them, and which also contains instructions upon the art of playing the flute with a pure tone and a good style."

#### VI TRANSLATOR'S INTRODUCTION

In a letter to Mr. Broadwood, dated November 15, 1868, Boehm wrote: 'I have at length finished it [this treatise]. There ought properly to be both a French and an English translation, but I cannot myself undertake them \* \* \* [y]y treatise will contain \* \* \* ; and the history of all my work and all my experience during a period of 60 years will be contained in one little book.' In August, 1871, he writes : "My work, 'Die Flöte und das Flötenspiel,' is in the press."

The preparation of the English edition of this last work of Boehm's has been a labor of love, and the writer hopes that its study will make still better known Boehm's very careful and complete investigations, and will lead to a full appreciation of his remarkable improvements in the flute. His greatest desire was to elevate the art of music, but he was also possessed of the true scientific spirit, and has described his designs and practical constructions very explicitly. In 1847 he wrote: "The surest proof of the authenticity of my inventions, I believe will consist in describing the motives I had in their development, and in explaining the acoustical and mechanical principles which I made use of ; for he alone is capable of carrying out a rational work, who can give a complete account of the why and wherefore of every detail from the conception to the completion." Judged by this criterion, Boehm deserves the highest credit, for he has given an account – almost beyond criticism, and perhaps the best ever given for any musical instrument – of the why and wherefore of the flute.

## TRANSLATOR'S INTRODUCTION vii

The first part of the present work covers the same subjects as did the one of 1847, but the treatment is more complete and practical. In addition to this there is much of value about the mechanism, and the care of the flute, while the second part on flute-playing is of great interest.

In 1847 stress was put upon the so-called scientific construction of the flute; in this treatise the scientific portions appear in truer relations to the subject. This should remove the slight cause for criticism which the earlier treatise seemed to present. To one who reads understandingly it is evident that, while the general treatment of the flute is a scientific one, the actual dimensions for construction are based upon experiment. No set of laws has yet been formulated which will enable one to calculate all the dimensions of a flute. This fact in no way lessens the value of Boehm's work ; his purposes were conceived and carried out according to scientific methods, and his finished work was the best practical realization of his ideals. Boehm is more than worthy of all the honor that he has received, not for scientific discoveries, but for practical improvements and artistic successes.

The full consideration of Boehm's contributions cannot be given here ; but to him we certainly owe the present system of fingering, – an astonishingly perfect one, – the cylinder bore, and much of the beautiful mechanism, which have completely revolutionized the instrument and have made the Boehm flute one of the most perfect of musical instruments.

## VIII TRANSLATOR'S INTRODUCTION

The text here given is a faithful, and usually a very literal, translation of the German. Boehm's writings possess both a historical and a scientific interest, and his inventions have been the subject of much controversy. It has seemed desirable, in giving his descriptions and explanations, to retain as far as possible, the forms of expression and even the wording of the original. Some traces of the German construc-

tions, no doubt remain. While a freer translation might be preferred by some, it is believed the one given is always intelligible and explicit. There has been a slight rearrangement of subject matter and of paragraphing. The use of emphasis, – indicated by italics in English, – which is very frequent in the original, has been omitted.

Eight errors in the original lithographed Tables of Fingerings, and a few typographical errors in the tables of acoustical numbers have been corrected; no other corrections have been found necessary.

All of the original illustrations are reproduced; the diagrams have been redrawn with only such alterations as are noticed in the descriptive matter ; the musical illustrations have been copied photographically from the German edition and therefore appear exactly as Boehm left them. In this edition there have been added several diagrams ( Fig. 4 and the note diagrams in square brackets), pictures of six flutes (Figs, i, 2, 9, 10, II, and 18), and three portraits of Boehm. The first portrait is copied from an old lithograph ; the second is from the original photographic portrait by Hanfstaengl of Munich, presented to the writer by

#### TRANSLATOR'S INTRODUCTION ix

Miss Anna Boehm, a granddaughter of our Boehm; the third is copied from Welch's "History of the Boehm Flute."

It was the writer's first intention to make somewhat lengthy annotations to the original text ; but these notes soon became so extended, and further study developed so much material, that it has now been decided to prepare a separate book on the history and construction of the modern flute. However it seems best not to abandon entirely the first plan, and many annotations by the translator will be found throughout the work; all such added matter is enclosed in square brackets, [ ]. These annotations have been confined, for the most part, to matters of fact ; while there may be differences of opinion upon some points, this is not the proper place for discussions which might lead to controversy.

The writer wishes to express his thanks to

Theobald Boehm and his sisters, of Munich, grandchildren of the inventor of the flute; when the writer first visited them, some years ago, they gave approval to this English edition, and now they have very kindly expressed this sentiment in the letter, a portion of which precedes this introduction. These friends have also given other assistance which is highly appreciated. He also wishes to thank his several friends who have placed their instruments at his disposal for study and illustration.

Dayton C. Miller.

Case School of Applied Science,

Cleveland, Ohio, November, 1908.

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THE FLUTE  
AND FLUTE-PLAYING

Part I— The Flute

UPON THE SYSTEM OF

Theobald Boehm

OF MUNICH

## I. INTRODUCTION

It is now more than sixty years since I first began to play upon a flute of my own manufacture. [In 1810, "at the age of 16 years he made for himself an instrument patterned after one with 4 keys, loaned to him by a friend. Then he began to blow the flute with gleeful enthusiasm in all his spare time, not especially to the delight of his friends and neighbors." – Zur Erinnerung an Theobald Boehm.]

I was then a proficient goldsmith and was also skilled in the mechanic arts. I soon endeavored to make essential improvements in the keys, springs, and pads of my flute; notwithstanding all my efforts, equality of tone and perfection of tuning were impossible.

## 2 THE FLUTE

because the proper spacing of the tone-holes required too great a spreading of the fingers. In order that the tone-holes might be made of proper size and be placed at the acoustically correct points, it was necessary to devise an entirely new system of fingering. I could not remodel the flute to this extent without sacrificing my facility in playing which had been acquired by twenty year's practice.

Notwithstanding all my success as an artist, the defects of my instrument remained perceptible, and finally I decided in 1832 to construct my ring-keyed flute, upon which I played in London and Paris in the following year, where its advantages were at once recognized by the greatest artists and by l'Academie des sciences.

As compared with the old flute, this one was unquestionably much more perfect. The tone-holes, through my new system of fingering, were placed in their acoustically correct positions, and one could play all possible tone combinations clearly and surely. As regards the sounding and the quality of the lower and higher tones there was yet much to be desired; but further improvements could be secured only by a complete change in the bore of the flute tube.

[Figures 1 and 2 are reproduced from Boehm's pamphlet of 1847, Ueber den Flötenbau und die neues-

ten Verbesserungen desselben. Fig. 1 shows his flute on the old system, as made in 1829, while Fig. 2 represents the new Boehm System Flute of 1832.]

#### BOEHM'S EARLIEST FLUTES

Fig. 1. Boehm's Flute  
Old System. 1829

Fig. 2. Boehm's Flute  
New System. 1832

#### 4 THE FLUTE

The method of boring, with a cylindrical head, and a conical contraction in the lower part, which was first improved by Christopher Denner of Nuremberg (born in 1655, died in 1707)., and later by Quantz [1697- 1773], Tromlitz [1726- 1805] and others, was nevertheless far from being in accordance with acoustical principles, as the places of the finger-holes had been borrowed from the primitive Schwegel or Querpfeife. This conical bore was in use more than a century and a half, during which no one made improvements in it.

I was never able to understand why, of all wind instruments with tone-holes and conical bore, the flute alone should be blown at its wider end ; it seems much more natural that with rising pitch, and shorter length of air column, the diameter should become smaller. I experimented with tubes of various bores but I soon found that, with only empirical experiments, a satisfactory result would be difficult of attainment.

[The flute of 1832, therefore, remained unchanged for fifteen years. Boehm says in his treatise of 1847, mentioned below : "With regard to all the alterations and improvements which have been made in the flute [after 1832], whose value or worthlessness I leave for others to decide, I had no part in them ; from the year 1833 to 1846 I gave no time to the manufacture of instruments, being otherwise engaged [in iron work]

and for this reason my flute factory was given up eight years ago in 1839."]

I finally called science to my aid, and gave two years [1846-1847] to the study of the principles of acoustics under the excellent guidance of Herr Profes-

#### PURPOSE OF THIS TREATISE 5

sor Dr. Carl von vSchafhützl [of the University of Munich]. After making many experiments, as precise as possible, I finished a flute in the latter part of 1847, founded upon scientific principles, for which I received the highest prize at the World's Expositions, in London in 1851, and in Paris in 1855.

Since that time my flutes have come to be played in all the countries of the world, yet my treatise, "Ueher den Flötcbau und dessen neuesten Verbesserungen" [Boehm quoted from memory; the actual title is Ueber den Flötenbau und die neuesten Verbesserungen desselben], published before that time [in 1847] by B. Schott's Söhne of Mainz, which contains complete explanations of my system with the dimensions and numerical proportions, seems to have had but little influence. Because of the many questions which are being continually asked of me concerning the advantages and management of my flute, it is evident that the acoustical proportions and key mechanism are not sufficiently well understood to enable one to help himself in case of accidental troubles and derangements.

There is need therefore of this work, which will be welcomed by all flute players, in which is given as complete a description as is possible of my flutes, and instructions for handling them, and which also contains instructions upon the art of playing the flute with a pure tone and a good style.

#### II. THE ACOUSTICAL PROPORTIONS OF THE FLUTE

All, wind instruments with tone- or finger-holes, whose construction requires very accurate proportions, can be improved only through the investigation of the principles of the good as well as the bad of existing

instruments, and through a rational application of the results ; the greatest possible perfection will be obtained only when theory and practice go hand in hand. When the calculation of the required data is undertaken, the questions to be first investigated are the dimensions and numerical proportions of the air columns and tone-holes of each separate instrument.

For this purpose I had prepared in 1846 a great number of conical and cylindrical tubes of various dimensions and of many metals and kinds of wood, so that the relative fitness as to pitch, ease of sounding, and quality of tone, could be fundamentally investigated.

The most desirable proportions of the air columns, or the dimensions of bore best suited for bringing out the fundamental tones, at various pitches, were soon found. These experiments show :

I. That the strength, as well as the full, clear quality of the fundamental tones, is proportional to the volume of the air set in vibration.

#### BORE OF TUBE 7

2. That a more or less important contraction of the upper part of the flute tube, and a shortening- or lengthening of this contraction, have an important influence upon the production of the tones and upon the tuning of the octaves.

3. That this contraction must be made in a certain geometrical proportion, which is closely approached by the curve of the parabola,

4. That the formation of the vibration nodes and tone waves is produced most easily and perfectly in a cylindrical flute tube, the length of which is thirty times its diameter : and in which the contraction begins in the upper fourth part of the length of the tube, continuing to the cork where the diameter is reduced one tenth part.

Since the dimensions most suitable for the formation of the fundamental tones correspond closely to those of theory, a flute of these dimensions, the length of the air column being 606 millimeters and its

diameter 20 millimeters, having a compass of about two octaves, would certainly be perfect as regards a full, pure tone, and ease of sounding. But in order to extend the compass to three full octaves as now required [in flute music], I was obliged, for the sake of freedom in the upper tones, to reduce the diameter to 19 millimeters and thereby again to injure to some extent the beauty of the tones of the first two octaves.

[In a letter written in 1867 Boehm says: "I have made several flutes with a bore 20 millimeters in diameter, therefore one millimeter wider than usual ; the first and second octaves were better, but of course

## 8 THE FLUTE

the third octave was not so good. I could, indeed, still play up to Cq, but from FgJ upwards the notes were sounded with difficulty, and if my lip did not happen to be in good order, I could not sound the higher notes piano at all. The flute, whether in the orchestra or in solo playing, is treated as the next highest instrument after the piccolo ; modern composers do not hesitate to write for it up to Cg ; therefore the bore of 19 millimeters diameter is certainly the best for general purposes."]

[The silver flute with a wood head which is shown in Fig. 10 has a bore of 20 millimeters; it is the only flute in C of this bore which the translator has ever seen. Its tone quality was directly compared with that of the flute shown in Fig. 9, having a bore of 19 millimeters. The result of the comparison was to corroborate the opinions of Boehm as expressed above.]

[Boehm later made the "Alt-Flöte," commonly called the "Bass Flute/" which is described in section XII ; the tube of this instrument has an inside diameter of 26 millimeters. Messrs. Rudall, Carte and Company make an "Alto Flute" in B<sup>^</sup>, having a bore of 20.5 millimeters. These instruments have the beautiful tone quality in the lower octaves, referred to above.]

A second obstacle which compelled me to depart from the theory was the impossibility of making a moveable cork or stopper in the upper end of the flute, so that its distance from the center of the embouchure might be increased or decreased in proportion to the

pitch of each tone ; a medium position for it must therefore be used which will best serve for the highest as

#### SHAPE OF EMOUCHURE 9

well as the lowest tones; this is found to be 17 millimeters from the center of the embouchure.

Next, the size and form of the mouth-hole (embouchure) must be determined. The tone producing current of air must be blown against the sharp edge of the mouth-hole, at an angle which varies with the pitch of the tone. When the air stream strikes the edge of the hole it is broken, or rather divided, so that one part of it goes over or beyond the hole, while the greater part, especially with a good embouchure, produces tone and acts upon the column of air enclosed by the tube, setting it into vibration.

By this means the molecular vibrations of the tube are excited, producing a tone as long as the air stream is maintained; it follows therefore that the tone will be stronger the greater the number of the air particles acting upon the tone producing air column in a given time. The opening between the lips through which the air stream passes is in the form of a slit, and a mouth-hole in shape like an elongated rectangle with rounded corners, presenting a long edge to the wide air stream, will allow more air to be effective than would a round or oval hole of equal size.

For the same reason a larger mouth-hole will produce a louder tone than a smaller one, but this requires a greater strength in the muscles of the lip, because there is formed a hollow space under the lip which is unsupported. More than this it is difficult to keep the air current directed at the proper angle, upon which the intonation and the tone quality for the most part depend.

#### 10 THE FLUTE

By a greater depression of the air stream towards the middle of the hole, the tone becomes deeper and more pungent, while a greater elevation makes the tone higher and more hollow. Consequently the angle

between the sides, of the mouth-hole and the longitudinal section through the axis of the air column, as well as the height of these sides, has an important influence upon the easy production of the tone. In my opinion an angle of 7 degrees is best adapted to the entire compass of tones, the walls being 4.2 millimeters thick; and a mouth-hole 12 millimeters long and 10 millimeters wide, is best suited to most flute players.

After the completion of these experiments I constructed many thin, hard-drawn tubes of brass upon which the fundamental tone C3

and also higher notes could be produced by a breath,, and easily brought to any desired strength without their rising in pitch.

The hissing noise heard in other flutes not being perceptible served to convince me that the correct dimensions of the tube and its smooth inner surface permitted the formation of the air weaves without noticeable friction. From this as well as from the fine quality of tone of the harmonics or acoustical overtones, can be inferred the perfect fitness of my tube for the flute; and with this I began the determination of the shortening or cutting of the air column, required for producing the intervals of the first octave.

#### LOCATION OF TONE-HOLES n

The simplest and shortest method is, naturally, to cut off from the lower end of the flute tube so much as will make the length of the air column correspond to each tone of the chromatic scale. To accurately verify these proportions, I made a tube in which all the twelve tone sections could be taken off and again put together, and which was provided with a sliding joint in the upper part of the tube to correct for any defects in tuning.

Since a flute cannot be made to consist of many separate pieces, all the tone lengths must be combined in one tube, and these lengths may be determined by laterally bored holes; the air column may be considered as divided or cut off by these holes in a degree determined by the ratio between the diameters of the

holes and of the tube.

The air column, however, is not as much shortened by a tone-hole as by cutting the tube at the same point. Even if the size of the hole is equal to the diameter of the tube, yet the air waves will not pass out of the hole at a right angle as easily as along the axis.

The waves meet with a resistance from the air column contained in the lower part of the tube, which is so considerable that all the tones are much too flat when they come from holes placed at the points determined by cutting the tube. And, moreover, the height of the sides of the holes adds to the flattening effect. The tone-holes must, therefore, be placed nearer the mouth-hole the smaller their diameter and the higher their edges.

## 12 THE FLUTE

Although one octave can be correctly tuned in this manner with small holes, yet for the following-reasons it is greatly to be desired that the tone-holes should be as large as possible.

1. Free and therefore powerful tones can only be obtained from large holes which are placed as nearly as possible in their acoustically correct positions.
2. If the holes are small, and are considerably removed from their proper places, the formation of the nodes is disturbed and rendered uncertain; the tone is produced with difficulty, and often breaks into other tones corresponding to the other aliquot parts of the tube [harmonics].
3. The smaller the holes, the more distorted become the tone waves, rendering the tone dull and of poor quality.
4. The pure intonation of the third octave depends particularly upon the correct position of the holes.

From accurate investigations it is shown that the disadvantages just mentioned, become imperceptible only when the size of the holes is, at the least, three fourths of the diameter of the tube [14<sup>^</sup> millimeters].

But in the manufacture of wooden flutes, the making of holes of such a size causes considerable difficulty. At first it appeared very desirable to make the holes of gradually increasing size from the upper to the lower ones; later this proved to be exceedingly disadvantageous, and I concluded that again a medium course is the best. Therefore I finally chose a constant diameter

#### SIZE OF TONE-HOLES

13

for all the twelve tone-holes from C3 to Q, which for silver flutes is 13.5 millimeters, and for wooden flutes 13 millimeters.

[Several Boehm & M endler flutes, of wood and of silver, which have been measured by the translator, show exactly the diameter of holes mentioned above. The reason why graduated holes are disadvantageous is no doubt given in the following extract of a letter v/ritten by Boehm, in 1862, to Louis Lot, the celebrated flute maker of Paris : "The flute-playing world knows that for six years I made all my silver flutes with graduated holes. \* \* \* The graduated holes are, in my opinion, the best, but the difference is scarcely appreciable. I have discontinued making them on account of the greater difficulty in the manufacture." The last sentence seems to state the three facts bearing on the question : the graduated holes are the best; their superiority is slight; the cost of their manufacture is greater. Today nearly all makers use two sizes of holes, and one eminent maker uses four.

With these dimensions, in order to produce the correct pitch, the center of the CgJ hole must be moved 5 millimeters above the point at which the tube would have to be cut off in order to produce the same tone. The amount of removal increases with each hole in the ascending scale, so that the C^ hole [thumb key hole] must be placed 12 millimeters above the point of section of the air column. In this manner the correct positions of the holes are obtained, and the tuning of all the notes of the first octave is rendered to the ear

as perfect as possible.

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## THE FLUTE

The notes of the second octave are produced, as it were, by overblowing- the tones of the first, by narrowing the opening in the Hps, and by changing the angle and increasing the speed of the stream of air; this results in producing shorter tone-waves.

In order to secure a greater compass of tones, it is necessary to use a narrower tube than the one best suited to the fundamental tone; or in other words a tube too narrow in proportion to its length. From this it results that the tones  $D^{\wedge}$  and  $D^{\wedge}f$  are of different quality from the next following, and it is first with the note  $E^{\wedge}$  that the relation between length and width is again restored.

For joining  $C^{\wedge}$  and  $E^{\wedge}$ , therefore, the flute should properly have three additional large holes for the tones  $C4\#$ ,  $D4$  and  $D4J$ . But there is only one finger available, and this must be used for the  $C.iJj$ : hole which must be so placed that it may ser\`e at the same time as a so-called vent hole for the tones  $D^{\wedge}$ ,  $DJ^{\wedge}$ ,  $D5$   $GgJ$ : and  $Ag$ . Theory, however, requires octave-holes for  $D4$  and  $Diif$ , which would also serve as vent holes for the twelfths,  $Ggfl$ : and  $A5$ , giving to all these tones a better quality, a purer intonation and a freer sounding.

But since I was unwilling to make my system of fingering more complicated, it was necessary to determine by experiment a size and position for the  $C^{\wedge}$  hole which would satisfy all of these demands. The  $C^{\wedge}J$  hole, as well as the two small holes for the  $D4$  and  $D4\#$  trill keys, must therefore be placed considerably above their true positions, and must be made correspondingly smaller.

## CALCULATION OF DIMENSIONS 15

For the exact determination of these, as well as for the other tuning proportions, I had a flute made with moveable holes, and was thus enabled to adjust all the tones higher or lower at pleasure. In this way I could easily determine the best positions of the upper three small holes, but it was not possible to determine the tuning of the other tones as perfectly as I desired ; for, endeavoring to produce an entire pure scale in one key. the tones were always thrown out of the proportions of the equal temperament, without. which the best possible tuning of wind instruments with tone-holes cannot be obtained.

Therefore, in order to determine with perfect accuracy the points at which the tone-holes shall be bored, one must avail himself of the help of theory. To form a basis for all the calculations of dimensions, and for the easy understanding of this, it seems not out of place to give as simply as possible an explanation of the fundamental acoustical laws.

As is known, the acuteness or graveness of tones depends upon the length and volume of the sounding body, and is proportional to the velocity of vibration which can be impressed upon the body. For the entire extent of musical tones, these constant relative proportions have long been known with mathematical precision; the following Table I gives these relations for all the tones of the equally tempered scale in the form of vibration numbers and string lengths. [The ratio of the number of vibrations of any tone in the equally tempered scale to the number of vibrations of the preceding tone is the twelfth root of 2; the numeri-

i6

## THE FLUTE

cal value of this ratio is 1.059463. As the numbers in this table are useful for various acoustical computations, they have been recomputed by the translator, and several typographical errors in Boehm's figures have been corrected.]

TABLE I

RELATIVE

RELATIVE

TONES

VIBRATION NUMBERS

STRING LENGTHS

Q+1

2.000000

0.500000

B

1.887749

0.529732

Bb or A#

1.781797

0.56123I

A

1. 68 1 793

0.594604

Ab or G#

1. 58740 1

0.629960

G

1.498307

0.667420

Gb or F#

I.4I42I4

0.707107

F .

1-334840

0.749154

E

1. 25992 I

0.793701

Eb or D#

1. 189207

0.840896

D

1. 122462

0.890899

Db or C#

1-059463

0.943874

c.

1 .000000

1. 000000

Here is shown the geometrical progression in which the vibration frequency of C<sup>^</sup>, which is designated the fundamental, is constantly increased throughout the scale, so that the number of vibrations of the octave, Ca.+i, has become double that of C<sup>^</sup>; at the

same time, shortening in equal progression, the string-length is reduced from 1.0 to 0.5.

With these relative numbers it is a simple matter to calculate the absolute vibration numbers corre-

#### TEMPERED SCALE

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Spending to any desired pitch, since any given vibration number bears to all the other intervals exactly the same proportion, as the relative number corresponding to this tone bears to the relative number of these other intervals.

For example, to calculate the number of vibrations of the tone C3, knowing the absolute number of vibrations of the Normal A3 to be 435 vibrations per second. We have the following proportion :

relative A3 : relative C3  $\wedge$  absolute A3 : absolute C3  
 1.681793 : 1.000000  $\wedge$  =: 435 : X

435x1.000000

= 258.65.

1. 68 1 793

If now this absolute number 258.65 be multiplied by each of the relative vibration numbers of the above table, one obtains the absolute vibration numbers of all the tones in one octave of the normal scale from C3 to C4. In this way one avoids the division by numbers of many places, which is necessary by the direct method of calculation.

In a similar way one calculates measurements of length, as soon as the theoretical length of the air column in any given system, corresponding to the string length 1.000000, is determined.

While the vibration numbers and theoretical pro-

portions of lengths for all instruments remain always the same, yet the actual lengths of the air columns are very different, because each wind instrument has its own peculiar length in consequence of its tone forma-

## 18 THE FLUTE

tion. For example, an oboe and likewise a clarinet (on account of the flattening effect upon the tone of the tube and mouth-piece) are much shorter than a flute of the same pitch; and even in the flute the actual length of the air column is less than the theoretical length corresponding to the given tone. The same is true to a less extent of a simple tube or a mouth-piece alone. Hence it happens that a wind instrument cut in two in its middle does not give the octave of its fundamental, but a considerably flatter tone.

In the case of the flute the flattening influence of the cork, the mouth-hole, the tone-holes, and the dimensions of bore is such that, altogether, it amounts to an air column of 51.5 millimeters in length, which in the calculation must be considered theoretically as existing, in order that the length of the air column shall exactly correspond to the length of the string of the monochord determined from the numbers and proportions of the table.

It will be found that the actual length of air column (and therefore also of the flute tube) from the center of a C3 hole, bored in the side of a long flute tube, to the face of the cork 618.5 millimeters, and that the length of the first octave from C3 to C4 is 335 millimeters, thus the upper portion is 51.5 millimeters shorter than the lower, and in calculating, this quantity (51.5 millimeters), must be taken into consideration.

By doubling the length of the octave one obtains as the theoretical air column the length of 670 millimeters, which serves as the unit of calculation, and

## LENGTH OF AIR COLUMN

19

from which, corresponding to the normal pitch, are obtained the following absolute vibration numbers and relative and actual length measures. [The numbers in this table have been recomputed by the translator.]

TABLE II

ABSOLUTE

THEORETICAL

ACTUAL

TONES

VIBRATION

AIR COLUMN

AIR COLUMN

NUMBERS

LENGTHS

LENGTHS

C.

517.31

335.00 mm

283.50 mm

B3

488.27

354-92

303-42

B3b AaS

460.87

376.02

324.52

A3

435-00

398.38

346.88

A3b G3#

410.59

422.07

370.57

Ga

387-54

447-17

395-67

G3b F3#

36579

473-76

422.26

Fa

345-26

501.93

450.43

E3

325-88

531-78

480.28

Esb DsS

307-59

563-40

511.90

D3

290.33

596.90

545-40

D3b C3#

274-03

632.40

580.90

C3

258.65

670.00

618.50

Evidently for the practical application, 51.5 millimeters must be subtracted from each of the theoretical lengths to obtain the actual lengths given in the third column, which determine the distances between the face of the cork and the center points for boring the tone holes.

### III. EXPLANATION OF THE SCHEMA

In Table II there is given only one set of normal dimensions; since the normal pitch [now known as international or low pitch: A=435] is by no means in universal use, it is often necessary to have measurements corresponding to various given pitches, but the labor required to make the requisite dimension calculations costs much time and trouble.

These inconveniences have caused me to design a "Schema" in which the basis of all the calculations of measurements of length is graphically represented. In this diagram the geometrical proportions of the lengths of a string, corresponding to the reciprocals of the vibration numbers in the equally tempered scale, are represented by horizontal and vertical lines ; while diagonal lines indicate the geometrical progression in which the length measures may be varied without disturbing their reciprocal proportions to the vibration numbers.

This graphic method was suggested by the plan of a monochord, on which by means of a moveable bridge the stretched string may be gradually shortened to half of its entire length, thereby producing all the intervals of one octave.

Now these proportions remain constant from the highest to the lowest musical tones, and the transition

fc

o &gt;

^ ^

c

o

Ok

3

'■^ CS) o"

## 22 THE FLUTE

from one inten'-al to the next can therefore be represented graphically, and my Schema has been founded upon these considerations. With its help and without calculation, the centers of the tone holes of all wind instruments constructed on my system, as well as the positions of the so-called frets of guitars, mandolins, zithers, etc., may be easily and quickly determined.

My diagram, Fig. 3, consists of three parallel horizontal lines of three different lengths, which start from a common vertical line, and are designated by A, B, and C. [In the original this diagram is given in half-size scale ; it is here reproduced about one-fifth full size. In either case, for actual use. it would need to be accurately redrawn to full size. The dimensions

shown on the diagram have been added by the translator, to make its construction plain ; all the dimensions are contained in Table II. A portion of the Schema drawn to full size, with dimension added, is shown in Fig. 4, on page 27.]

The central line represents the air column of a cylindrical flute tube, open at both ends, corresponding to the stretched string of the monochord, whose fundamental tone is C3 of the scale founded on the normal pitch A3 = 435 vibrations. The entire length of this air column, and therefore of the line B, for the fundamental tone C3 is 670 millimeters. The sectional lengths for the tones of the chromatic scale, calculated from the absolute vibration numbers for this pitch, and expressed in millimeters [see Table II], are given by the points of intersection of the line B with the vertical lines.

#### GRAPHIC LOCATION OF HOLES 23

There is thus represented a standard of measurement, expressed in millimeters, to be taken from the upper end of the diagram along the line B. This diagram gives the actual dimensions of my flute, measured from the cork, if from each relative measure is subtracted the 51.5 millimeters (represented by the small cross line) which was previously added to complete the theoretical air column [see page 18]. More than this, all the data for calculation are present, if beneath the points of intersection of the length measures the absolute vibration numbers are written.

Since these standard measures correspond only to the normal pitch, it is necessary to be able to lengthen or shorten the reciprocal distances of the tone-holes to correspond to varying pitches, with ease and without disturbing their reciprocal proportions.

This can be accomplished without computation by means of diagonal lines on the diagram which pass through the points of intersection of the vertical lines with the line B, both upwards and downwards to the points where the vertical lines end in the two parallel lines A and C. In this way are shown two new sets of measures, one corresponding to a pitch a half tone sharper, the other to one a half tone flatter.

A flute made to the shortened measurements of line A, will be exactly half a tone sharper than the normal pitch, while one made upon the longer dimensions of line Cj will be exactly a half tone lower than the nonnal pitch. Now as these diagonal lines may be looked upon as continuous series of tone-hole centers, which, in a geometrical progression, gradually approach

24

## THE FLUTE

each other above, and in the same way recede from each other below, it follows that the relative proportions of the distances of these points remain continually unchanged, wherever the diagonal lines are intersected by a new line parallel to the line B.

It is possible therefore, as shown in the diagram, to draw between the lines A, B, and C six parallel lines, whose pitch difference is one eighth of a tone ; and at will many other lines may be drawn, the intersections of each of which with the diagonal lines will give correct dimensions. The only remaining question is which of these new lines will correspond to a given pitch.

In order to answer this question one must first express the pitch difference between the given pitch and the normal, in millimeters, which will give the difference between the length of the air column of the given tone, and the length for the same tone in normal pitch shown on line B. This will also determine the position of a new vertical section line crossing the line B, corresponding to the given tone.

If the desired pitch is higher than the nonnal, the vertical section line through the point on line B, corresponding to the new pitch, is to be extended upward toward A; while if the pitch is lower than the normal, the vertical line is to be extended downward toward C.

In either case the intersection of the vertical line with a diagonal line is the point through which a new

line parallel to B is to be drawn. The conversion of pitch difference into longitudinal measurement may be carried out as follows. The pitch to which an

#### SCALES FOR VARIOUS PITCHES

25

instrument is to be constructed may be given by a tuning-fork, a tuning pipe, or by number of vibrations, and in the rules either an A or a C may be used.

For example let there be given by a tuning fork an A<sub>3</sub> of 430 vibrations which is 5 vibrations flatter than the normal A<sub>3</sub> of 435 vibrations. In this case it is necessary merely to draw out the head joint of a normal flute until it is exactly in tune with the tuning fork (which naturally the ear determines), in which case the length drawn out will be found to be 4.63 millimeters. If, however, the given pitch is higher than the normal, for example A<sub>3</sub> = 445 vibrations, then, since the flute cannot be shortened, the head joint is to be drawn out till the tone B<sup>^</sup> is in unison with the A<sub>3</sub> of the fork. The length drawn out will be found to be 13.40 millimeters; and since the distance between the centers of the B<sub>0</sub>( ) and A<sub>3</sub> holes of the normal flute is 22.36 millimeters, it follows that the air column corresponding to the A<sub>3</sub> of the fork is shorter than that of the normal flute by 8.96 millimeters.

If the pitch differences are given by vibration numbers, then the conversion into millimeter measures must be calculated. The vibration numbers are inversely proportional to the lengths ; and the vibration numbers A<sub>3</sub> = 430 and A<sub>3</sub> = 445 are to the normal vibration number A<sub>3</sub> ^ 435, as the relative normal length 398.38 millimeters is to the required lengths. If now the numbers 435 and 398.38 are multiplied together, and the resulting product is divided by the numbers 430 and 445, the quotients are 403.01 and 389.42 which then represent the numbers of milli-

## 26 THE FLUTE

meters in the relative lengths, to which the vibration numbers have been converted. If these measurements correspond to the given vibration numbers 430 and 445, then the differences between them and the length of the normal A3, 4.63 and 8.96 millimeters, must correspond to the vibration differences of 5 and 10 vibrations.

Therefore a vertical section line drawn through the line  $\beta$  at a point 4.63 millimeters distant from the center of the A3 hole in the direction of  $A^j$ , will correspond to  $A_3 = 430$  vibrations ; and a section line 8.96 millimeters distant from the A3 hole in the direction of  $A_{3II}$ : will correspond to  $A_3 = 445$  vibrations.

[Boehm's original description of the Schema was published in the Kunst und Gewerheblatt in Munich. October, 1868. In this account a diagram accompanies the preceding explanation, but it is omitted in "Die Flöte." In Fig. 4 this drawing is given, with some elaboration. It shows, drawn accurately to full scale, a portion of the Schema. The ratio of the distances between the parallel lines A, B, and C is obviously the same as of the distances between any three successive vertical lines.]

The desired points of intersection will, in the manner mentioned above, be obtained from the diagonals leading upward or downward, and the results of this method of procedure will be found to be perfectly accurate.

Since the relative proportions of the numbers of vibration and the measurements remain unchanged

## THE TUNING SLIDE

27

throughout the diagram, it is immaterial whether the given tone is an A, a C, or any other; and if the diagram is not sufficiently long for lower tones, it can

be extended at will.

Air 4603 =AS

i76.02-> 3H8.3S-^ 422.07-^

Fig. 4. A Portion of the Schema

Actual Size

^4=410.6^^1'

For each successive lower octave one has only to double all the dimensions; the accuracy of the drawing controls itself, for any error made would be at once evident by the drawing of the diagonal lines.

From this explanation it is evident that a flute can be in the most perfect tune at one pitch only, and that any shortening or lengthening above the tone-holes must work disadvantageously upon the intonation; in the first case the higher tones as compared with the

## 28 THE FLUTE

lower are too sharp, and in the second case [drawing the tuning side], on the contrary, the lower tones are too sharp as compared with the higher.

Obviously, these difficulties are no more overcome by a longer or shorter head joint, than by a simple drawing of the slide; this drawing out must not be more than two millimeters. Small pitch differences can, indeed, be compensated, so far as the ear is concerned, by a good embouchure. Accordingly I make the head joints of my flutes about two millimeters shorter than is required for perfect tuning, so that one may not only draw out the head to lower the pitch, but that he may make it somewhat sharper. However

it is best in ordering a flute to specify the pitch as accurately as possible, and at the same time to mention whether the player directs his embouchure inwards or outwards, as this also produces a considerable effect on the pitch.

#### IV. THE MATERIAL

That the tones of a flute may not only be easily produced, but shall also possess a brilliant and sonorous quality, it is necessary that the molecules of the flute tube shall be set into vibration at the same time as the air column, and that these shall, as it were, mutually assist one another. The material must possess this requisite vibration ability, which is either a natural property of the body, for example as in bell-metal, glass and various kinds of wood, or has been artificially produced, as in the case of hardened steel springs and hard-drawn metal wire.

Now in both cases the excitation of the vibrations requires the expenditure of energy proportional to the mass of the material. Consequently the tones of a flute will be more easily produced and the development of their full strength will require less effort in blowing, the less the weight of the flute tube.

Upon a silver flute, therefore, the thin and hard drawn tube of which weighs only 129 grams, the brightest and fullest tone can be brought out and maintained much longer without fatiguing blowing, than can be done on a wood flute, which even when made as thin as possible still has double the weight, namely 227<sup>^</sup> grams. [Boehm's silver flute, complete, weighs about 330 grams, being considerably lighter than those of most other makers.]

#### 30 THE FLUTE

Any variation in the hardness or brittleness of the material has a very great effect upon the timbre or quality of tone. Upon this point much experience is at hand, for flutes have been made of various kinds of wood, of ivory, crystal-glass, porcelain, rubber, papier-mache, and even of wax, and in every conceivable way to secure the various desired results.

Heretofore all of these researches have led back to the selection of very hard wood, until I succeeded in making flutes of silver and German silver, which now for twenty years have rivaled the wood flute. [Silver flutes were first introduced by Boehm in 1847.] Notwithstanding this it is not possible to give a decisive answer to the question "What is the best?"

The silver flute is preferable for playing in very large rooms because of its great ability for tone modulation, and for the unsurpassed brilliancy and sonorousness of its tone. But on account of its unusually easy tone-production, very often it is overblown, causing the tone to become hard and shrill ; hence its advantages become of full value only through a very good embouchure and diligent tone practice. For this reason wooden flutes on my system are also made, which are better adapted to the embouchures of most flute players; and the wood flutes possess a full and pleasant quality of tone, which is valued especially in Germany.

The silver flutes are made of a yV fine alloy [United States coin silver is tu fine; sterling silver is tVxtV fine] ; and for the manufacture of wood flutes I usually employ either the so-called cocus wood,

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#### VARIOUS MATERIALS 31

or the grenadille wood of South America. The first, of dark or red-brown color, is especially desirable because of its brilliant tone, notwithstanding that this wood contains a resin, which, in very rare cases, induces an inflammation of the skin of the lip. To obviate this difficulty, as well as to secure a very pleasant ringing-quality of tone in the high notes, many will prefer black grenadille wood. Ebony and boxwood are now used only for the cheaper grades of instruments.

For my flutes only selected good and perfect wood is employed, and if a piece develops a defect during the working, it is at once cast aside, that no more time and labor may be lost.

However, a flute which is entirely free from faults may become cracked by improper handling, against which no guarantee is possible. Both the cause and the means of preventing such accidents should be understood, and I will therefore return to this subject later, under the heading, Treatment of the Flute in General.

[Boehm frequently combined two materials, making the body of silver and the head of wood. It was in his later years that he most strongly advocated this combination, though he had constructed such flutes in his earlier years, certainly prior to 1866. A silver flute with a wood head, the latter "thinned" and without metal lining, is shown in Fig. 10. Notwithstanding Boehm's recommendation, such composite instruments have not grown in favor.]

## V. THE SYSTEM OF FINGERING

### (a) General Description

Having determined the dimensions and material best suited for the flute tube, it was then necessary to devise a system of fingering by which all scales, passages and trills in the twenty-four keys could be played, clearly, certainly, and with the greatest possible ease. [The chronological order is not accurately stated, for the system of fingering was practically completed in 1832, while the dimensions and material, as described above, were altered by the introduction of the cylinder bore silver flute in 1847.]

This task I endeavored to accomplish in the following manner : since the fifteen tone-holes of my flute tube could not be covered by means of the fingers, because the holes were too large and in some instances too far apart, it was necessary to furnish them all with keys, and these had to be so arranged that they could be opened or closed at will.

For this purpose but nine fingers are available, since the thumb of the right hand is indispensable for holding the flute. The deficiency in fingers must therefore be made up by mechanism, whose systematic joining makes it possible with one finger to close several keys at the same time. I have accomplished this by means of moveable axles, to which part of the

Theohald Boehm

Aged GO

At Ihc lime <if the perfection of the cylinder bore, covered hole, flute  
His favorite portrait

#### SYSTEM OF FINGERING

33

keys are fastened, and on which part of the keys are merely hinged ; by means of clutches underneath, the latter may be made to act upon the axles.

These axles may be lengthened as desired, so that the attached keys are manipulated at distances within reach of the fingers ; the means for accomplishing this had to be sought in the design of the key mechanism. After mature consideration of all the possible tone combinations and finger movements I made many sketches of mechanisms, in my efforts to find the best methods of key connections. In such matters only actual trial can determine which is best. I constructed three entirely different model flutes, and after careful trial of all the advantages and disadvantages that model of my flute which has since become well known proved itself in all respects the most suitable.

I have retained the three foot keys for CgJ, D3, DgJ, for the little finger of the right hand, in the form already well established, the two trill keys for D4 and D4# are brought into use only for the highest tones B^\) and Bg ; hence the number of keys to be arranged is reduced from fifteen to ten, to play which there are still eight fingers available.

There now arises the question, "Which method of construction, that with open keys or that with closed keys, is the most servnceable ?"

I chose the open keys, to obtain the greatest possible ease in playing, since these easily follow the movement of the fingers, and they require only weak springs for their quick raising; on the contrary, closed

#### 34 THE FLUTE

keys for stopping large holes air tight require strong springs, and their motions are contrary to those of the fingers.

After the ten tone holes from E to C<sup>J</sup> were provided with separate, easily moving keys, the eight fingers were placed upon them in the most practical arrangement permitting the natural holding of the flute; then as many keys were closed as could be done with entire convenience ; there remained open only two holes for G and B [which when closed give F<sup>#</sup> and B<sup>^</sup>] for which the missing fingers must be provided by a mechanical contrivance.

For this two key combinations were necessary, namely the clutches for connecting the E, F, and F<sup>#</sup> keys with the lengthened moveable axle of the G key, and the clutches of the B<sup>\</sup>) and the F<sup>J</sup> keys connecting with the axle of the B key.

As is shown in the following drawing (Fig. 5), the two keys G and B may be closed by means of the connected keys, without changing the lay of the fingers, and when the fingers are lifted the keys open of themselves by means of their own springs; thus one can play them at will.

In this way that very troublesome sliding from keys and tone-holes required on the old flute is entirely done away with, and one can certainly and easily play all possible tone combinations from low D<sup>3</sup> to high A<sup>5</sup>. In my system each scale requires all the fingers, and consequently they are all equally exercised, thus a player is in a condition to play in all keys with equal purity, certainty, and ease.

#### GJ KEY 35

In the following table of fingerings, those desig-

nated "irregular" may be used not only for facilitating certain passages, but may also be made valuable in many cases for enharmonic differences, such as between F# and G^.

The practicability of my system of fingering has long demonstrated itself not only in its use by artists, but also by beginning students who learn to play the scales and trills in all keys in much shorter time than was possible on the old flute.

The changing from the old flute to the new is not nearly so difficult as most players imagine. Ordinarily it requires only about two weeks for one to become familiar with the mechanism and the table of fingerings ; and one will find compensation for the necessar)-- trouble in the clear, smooth and easy production of the tones.

#### (b) The Gjt Key

Since the unlearning of the former fingering appears to be a great difficulty to many, artists and instrument makers have endeavored to adapt the fingering of the old flute, either wholly or in part, to my flute tube. For this reason there has been made in Paris, for many years, an alteration of my open G} key, which makes it like the closed G# key in its action. The use of this has spread somewhat, since it accommodates players of the old flute who can thus retain the former fingerings for G and GJ. [Reference is here made, not to the usual closed G# key, but to the "Dorus" G# key.]

### 36 THE FLUTE

In the planning- of my system of fingering, I made the G# key to stand open, hke all the rest, only after mature consideration of all the advantages and disadvantages in acoustical, mechanical, and technical aspects. The open key is advantageous because its motion is the same as that of the little finger of the left hand, and because of the weak spring required, its "play" is very light and convenient.

A combination of a closed G^t key with an open A key would cause not only an entirely unnecessary complication in the key mechanism, and be a disadvan-

tage from an acoustical aspect, but it would at the same time increase the difficulties of playing.

In order that a closed G# key may stop the large tone-hole air tight it must be provided with a strong spring, and it follows that the opening of the same requires a correspondingly greater force in the little finger of the left hand, than the pressing down of an open key which is held aip only by a weak spring. But of still greater importance is the strength required in the third or ring finger in closing the A key, since this finger must overcome not only the spring required to quickly raise both of the combined keys, but at the same time must overcome the strong closing spring of the GJ key. [These arguments apply to the Dorus G# key, and, in a modified form only, to the duplicate closed GJj: key mentioned below.]

It is easily seen that there is thus a loss in facility of playing in general, and, further, that all trills with these keys, and especially the trill G# with A, become much more difficult, than with the easy moving, open

#### H KEY 37

standing keys. Moreover, in the frequent combinations of the tones GJ or A\) with the lower tones FJt, F, E, Eb, and D, the little finger of the left hand must move in a direction contrary to that in which the fingers of the right hand are moving at the same time.

That it is easier to make similar motions with the fingers of both hands simultaneously, rather than contrary motions, and therefore that playing with a closed GJ key is the more difficult, no one will deny. Yet there is another difficulty from an acoustical aspect ; because of the connection of the GJj: key with the A key, the A hole cannot be opened by itself, the G# hole being always open at the same time ; this causes the Eg to be too sharp, and its production is interfered with. The production of this tone is a little more certain, when the G# hole remains closed ; and in rapid alternations, also in delicate slurring together of the E^ with other tones such as G^^, A4, A5, A3, etc., the advantage is very perceptible.

Finally, this complication of the mechanism is wholly superfluous, since each one of these two keys

has its own proper finger, and each can be easily opened or closed in the most natural and simplest way in my system. The above mentioned difficulties appear to have long been apparent in Paris, since a special lever has been added so that the difficult trills may be made with the strong first finger of the ring hand.

And yet again a second GJ hole has sometimes been bored in the flute tube and provided with an independent Gf key. [This is the closed G# key now in common use.] In both of these cases the mechanism

### 38 THE FLUTE

is rendered still more complicated. I have no objection to make, if amateurs, with little time or zeal for practice, and who will be satisfied with playing in a few keys only, when changing from the old flute to the new, believe they will find the closed GJj: key the easier ; yet I hold that it is wrong to instruct beginners in this way, since they will learn to play in all keys more easily, and consequently more quickly, by following my finally completed system.

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## VI. TABLES OF FINGERINGS

### REGULAR FINGERINGS

of the chromatic scale  
for the newly constructed flute of

Theobald Boehm

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REGULAR FINGERINGS

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For facility in playing, the two B<sup>j</sup>'s f TV ^

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can be taken with fingering for Bt],

^

if the B key is closed by the thumb pressing on the B|j lever.

The irregular fingerings may be used not only for facilitating certain passages, but also may be made valuable in many cases for enharmonic differences, such as between F<sup>^</sup> and G\).

[The use of the schleif-key on the ordinary flute is the same as with the bass flute, which is explained

on page 70; see also page 50.]

42 TRILL FINGERINGS

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TRILL FINGERINGS 43

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TRILL FINGERINGS

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Fig. 5. Key Mechanism

#### VII. DESCRIPTION OF THE KEY MECHANISM

In order to give a clear idea and explanation of the key mechanism of my flute, I have represented it in full size, Fig. 5, projected on a plane, and below have shown a side view of the inner parts which are not visible to the eye.

In the latter view are shown metal strips, which in the metal flute are soldered to the body, and in the wooden flute are screwed on, forming the supporting points of the mechanism. Below these strips, and exactly corresponding with the drawing above, the dimensions of the axles of the separate keys and clutches, as well as all the joints of the mechanism, are indicated by right angled lines and figures.

The whole collection of keys is divided into four parts which are designated in Fig. 5 by A, B, C, and D. Fig. 6 is a cross section of one key. Fig. 7 is a clutch

Fig. 6. Fig. 7. Fig. 8.

#### Details of Key Mechanism

with its pin, and Fig. 8 represents one of the moveable hinge tubes slipped off from its axle.

## THE FLUTE

We will take first for the explanation of the mechanism the drawing of the key-group A.

In the upper line the foot keys I, II, and III are represented, and in the side view beneath, the separate joints of the mechanism are shown, the lengths of which are indicated by the perpendicular lines below the metal strip, designated by the figures i to 7.

The three pillars with spherical heads, a, b, c, which form the supporting points of the mechanism, are united to the metal strip and soldered, while the strip is soldered or screwed onto the foot joint.

In the spheres a and h are threaded pointed screws which form the pivots on which turns a steel axle (from I to 5) the ends of which have conical holes.

The C<sub>f</sub> key, I, turns upon this axle ; this key is soldered to the hinge tube i to 2, and by means of a loop it connects with the hinge 3 to 4 which carries the lever arm (C<sub>k</sub>j lever), all being joined into one continuous piece. The D key II is likewise soldered to a hinge (2 to 3) and being placed inside of the loop, the two keys are slipped over the axle ; the key II is then made fast to the axle by a small pin passing through both. On the upper end of the axle (at 4 to 5) a lever arm is soldered, so that the axle and the D key move with it. These two keys are provided with springs which hold them open, and with rollers screwed onto the lever arms at right angles ; by pressing on the rollers one can at will close one key, or through their coupling at the loop, both may be closed together.

The closed D $\sharp$  key III is provided with a strong spring, and moves on an axis, screwed into the sphere

## KEY MECHANISM

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b, whose sharpened end (at 5) forms the pivot of the moveable axle.

The springs for the keys I and II are firmly-inserted in the little posts marked thus, \*, and push against the hinges by means of small blocks which are soldered fast ; the spring for key III is fastened in the spherical pillar c.

The key group B contains two moveable axles from 8 to 15 and from 16 to 20. The G key VII is soldered to the axle, at 14 and 15, which turns on the pivots of the spherical pillars d and e. Next to this key is the hinge tube 13-14 to which the Fj: key VI and a half of the loop clutch is soldered.

The other half of the loop is fastened to the second moveable axle, and since the two half loops touch one another, the two moveable axles may be coupled together.

This FJ key is played by the first or index finger of the right hand.

Next to this is the small hinge piece 12-13, which is fastened to the steel axle by means of a small pin. On this hinge piece there is soldered a side wing, against which presses an adjustable screw attached to the shank of key VI. This screw must be so adjusted that when pressing down the F# key VI the steel axle is turned and through this the attached key G VII is closed.

If now the two other keys F V and E IV, which are played by the second and third fingers, are mounted in exactly the same fashion and are each coupled with the steel axle, then by pressing down either of these

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48 THE FLUTE

keys, separately or together, the G key VII will be closed each time ; thus four keys and consequently four tone-holes can be opened or closed at will by three fingers. It is by this contrivance that one of the lacking fingers is replaced.

We come now to the upper half of this group.

Upon the steel axle which turns between the two pivots at 16 and 20 there is soldered a hinge, which extends from 16 to 18 and upon which at 16 there is the half loop for coupling with the lower steel axle, and at 17 and 18 is attached a sphere which serves as an ornament.

The Ajj: key X is soldered to the hinge tube 18-19, and placed next to this sphere. This key is played by the middle finger of the left hand, and by means of its adjusting screw presses upon the wing of the hinge 19-20, through which the B key XI is closed.

Since this key is connected to the steel axle by a pin near 19, and is coupled at 19 with the A# key X by the clutch, and at the same time by the loop at 14-15 it is coupled with the lower steel axle, this B key XI is itself closed by each pressing of the A# key X and also by pressing the F# key VI. It is clear that by these couplings still another finger is replaced, and consequently by means of this mechanism six keys can be played entirely at will by four fingers.

Into the upper side of the spherical pillar / is screwed an axle, the point of which forms the pivot at 20. Moving on this axle are the two keys C XII and C<sup>^</sup> XIII. The first is soldered to the hinge tube 21-22 and is played by the thumb of the left hand.

#### KEY MECHANISM

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The second, namely the Cjt key, as well as its lever, is soldered to the hinge tube 22-23, and is played by the

first or index finger of the left hand.

The group C consists of two separate keys, which move on the axle screwed into the spherical pillar h. The Gif key VIII, as well as its lever, upon which presses the fourth or little finger of the left hand, is soldered to the hinge 24-25. The A key IX which is played by the second or middle finger, is soldered to the hinge tube 25-26.

The group D contains likewise only two keys, namely the two trill keys for D and DJf. The DJf key XV and its spring hook are soldered to the hinge tube 29-30, and this tube in turn is soldered to the upper end of the long steel axle which turns on the pivots of the two spherical pillars k and /. On the lower end of this axle is the short piece of tube 27-28, which is connected with the axle by a pin; soldered to this tube is the Dii lever which is played by the third finger of the right hand. Between these two pieces is placed a long hinge tube which reaches from 28 to 29. Upon the upper end is soldered the D key and at the lower end the corresponding D lever, which is played by the second finger. Both keys are provided with strong closing springs at 29 and 30.

Besides these keys there is still to be provided a lever next to the C key XII, which can be pressed with the thumb of the left hand, at the same time that the C key is closed, thus closing the B key XI also. This lever is provided with its axle and spring, and serves in many cases to facilitate the playing. [The spring

## 50 THE FLUTE

is not shown in the original drawing. The B\ ) thumb lever is the invention of Briccialdi, an Italian flutist. It is Briccialdi's form of this lever that is in almost universal use today. Boehm later adopted the substitute B^ lever shown in Fig. 5. He seems never to have regarded it as an important part of the flute; it is used only incidentally in the Tables of Fingerings.]

Further, as the drawings show, all the springs, with the exception of that for closing the lower D\$ key III, are fastened in the little pillars designated with a \* ; these springs press upon little hooks soldered to the hinge tubes, in such a way as to close the two trill keys

D and DJf, and to hold all the other keys open.

These explanations all correspond to the flutes made by the firm "Th. Boehm & Mendler in München."

[In addition to the mechanism as described above, Boehm always recommended the "Schleif" key, referred to in the original only under the Bass Flute (page 70). It is literally a "loop" key; it determines the formation of a loop in the sound wave, giving freer speech and greater purity of tone, especially when playing pianissimo. Its application to the ordinary flute is the same as to the bass flute, which is shown in the supplementary Table of Fingerings, on page 71. The schleif-key, which is played by the left thumb, is shown in Fig. 9.]

[Figures 9, 10 and 11 have been added to show the appearance of the several styles of flutes made by "Th. Boehm & Mendler in München," when these instruments had reached their highest development. The flute shown in Fig. 9 was made in 1875 for Dean

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Fig. 9. 10. 11.

Flutes made by Th. Boehm & Mendler

FLUTES BY BOEHM & MENDLER

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H. B. Fine, of Princeton University. The flute is of silver with a gold embouchure, and is provided with the schleif-key, referred to above. Also this picture shows the crutch, described on page 61. The flute shown in Fig. 10 was made in 1879 for Rev. Rush R. Shippen, of Brockton, Massachusetts. It has

a silver body with a thinned wood head, referred to on page 31 ; the foot keys extend to B# ; and the bore is 20 millimeters, reference to which is made on page 8. Fig. II shows a wood flute made in 1881 for Mr. Joseph Shippen, Attorney, of Seattle, Washington; it is one of the last instruments made before Boehm's death. The mechanism of all these instruments is exquisitely proportioned and finished, and the tone is very easily produced and is pure and full in quality. The three flutes have the open G# key, Boehm's B\ lever, Bt] trill, and gold springs. In general the mechanism corresponds to the drawing. Fig. 5 ; and the scales of all follow very closely the dimensions of the schema.]

#### VIII. CARE OF THE MECHANISM

##### (a) Repairs

Even though kept from violent injuries, the flute, like other mechanisms, will occasionally need repairs.

In practical use the keys move up and down a countless number of times, and all metals being subject to wear, the appearance of defects from this cause is unavoidable, even in the most solidly constructed mechanisms.

A spring may break or lose its elasticity ; the oil, with which the axles and pivots must be covered, will become thick and sticky with time, and especially by the entering of dust, hindering the easy movement of the keys; or it may be necessary to replace an injured pad.

In all these cases it is necessary to remove the keys from the body and sometimes to take the mechanism to pieces. A person with some experience who has made himself familiar with the mechanism, and is provided with the few necessary tools, will have no difficulty in doing this. Every flutist should be in a position, therefore, himself to undertake small repairs, and he should not trust his instrument to incapable hands.

(b) The Keys

The unscrewing and taking apart of the key mechanism is to be performed in the following manner.

First, all of the springs, designated by a \*, Fig. 5, in each key group in which one or more keys are to be taken away, must be unhooked. This may be accomplished by means of the little fork represented in Fig. 12, with which the outer ends of the springs can be

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Fig. 12. Spring Fork

pushed far enough backwards to disconnect them from the little hooks.

For the foot keys of Fig. 5, group A, turn the pointed screw a backwards so that the steel axle with the C<sup>I</sup> and D<sup>II</sup> keys attached can be taken out. For turning the screws a screwdriver of the form shown in Fig. 13 is convenient.

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Fig. 13. Screw Driver

If the pin of the D key II, which projects a little below, be drawn out, both keys are loosened and can be pushed off the axle. [The translator would advise, unless there is urgent need, that these pins should not be removed. For the purposes of cleaning, it is

sufficient to remove the several groups of keys from the body, and to clean these groups without separating

#### 54 THE FLUTE

them into single pieces.] By unscrewing the small steel axles on which the rollers turn, these may also be removed from the lever arms.

To remove the DJj: key III, unscrew the steel axle and draw it out of the hinge.

By unscrewing the pointed screw d the lower section 8 to 15 of group B may be taken out, and likewise the upper section 16 to 20 by unscrewing the upper steel axle which forms the pivot at 20; the keys can be slipped off the moveable steel axles as soon as the pins through the clutch joints are pushed out.

To remove the C key XII, partly draw out the steel axle which goes entirely through the Cfl: key XIII.

In the group C the two keys G# VIII and A IX, in similar fashion, are taken off by withdrawing, partially or wholly, the steel axle which is screwed into the sphere h.

For the removal of the two trill keys D XIV and D# XV of group D, loosen the pointed screw in the spherical pillar /. The D key XIV as well as its hinge can be drawn off the steel axle as soon as the pin through the lever arm at 28 (DJ: lever) is pushed out.

When taking off and separating the key mechanism, it is best to lay each separate piece in its proper order on a sheet of paper ; this will much facilitate the putting together, and it will not be so easy to interchange or lose anything. Each piece can then be readily cleaned and polished.

All the surfaces may be cleaned with a cloth or chamois skin, and the inside of the hinge tubes with a small feather or a tuft of cotton which may be pushed

#### CLEANING KEYS 55

through the little tubes with a small stick of wood, etc. [or be drawn through with a fine copper wire].

After this cleaning the surfaces may best be polished with a piece of fine glove leather [chamois skin] and a fine polishing brush with the application of a little rouge, such as is used by jewellers.

When putting the mechanism together again, all the places at which rubbing occurs must be properly oiled. For this purpose watch oil is the best, but one may also use neats-foot oil or perfectly pure olive oil which has stood in the sun for a time and thereby been purified by sedimentary precipitation.

The steel axles should be wiped with a little piece of cloth slightly wet with oil, and the pointed screws (pivots) are best oiled with the point of a wooden toothpick. One should not use more oil than is really necessary for the protection of the rubbing surfaces.

In putting together and screwing on the mechanism, as is self-evident, one must in each particular follow exactly the reverse order to that which was used in taking the instrument apart. It is necessary in each key group first to join the pieces, after sliding them over the steel axles, by tightly inserting the pins; the groups of separate keys are screwed on, and finally the springs are hooked.

#### Fig. 14. Tweezers

For holding the little screws, pins and springs, tweezers such as are shown in Fig. 14, are useful.

## 56 THE FLUTE

For cementing leather or cloth [or cork] linings which have fallen off the keys, etc., a proper solution of schellac in alcohol serves best.

### (c) The Key Pads

These pads are made from a strong cloth-like stuff of fine wool [felt]. In order that the pads may close

the holes air tight, these felt disks are covered with a fine membrane (skin) ; this membrane is usually doubled, so that any accidental injury to the pad shall not become troublesome all at once.

The pads are covered over on the back side with little sheets of card and a hole is punched through the center, so that they may be screwed fast in the key cups. It is hardly possible to make the key cups always come exactly to the edge of the tone-holes, the pads are therefore made of such thickness that there is left a little space, then by underlaying of card or paper disks this may be filled till the pad fits perfectly all around. The failure of the pad to close the hole at particular points can be remedied by using pieces of paper cut in crescent shape.

The pads are held by screws, the nuts being soldered to the key cups, and under the heads of the little screws there are silver washers, which must be allowed to press the pad neither too tightly nor too lightly ; in the first case little wrinkles are formed in the skin of the pad which interfere with the air tight closing, in the second case air can escape through the cup.

#### ADJUSTING PADS 57

If a washer is too loosely held by its screw, it may be set in vibration by certain tones, producing an audible buzz which is unexplainable to many. It has happened that flutes have been sent from distances of several hundreds of miles for repair on which there was nothing wrong except that one single screw was not sufficiently tight.

The main point about the pads is that each separate key must close exactly air tight; then when the pressing of one key by another is required, this can be completely regulated by means of the regulating screws applied by me.

When one key acts upon another, as the E key upon the G key, one can determine by seeing light between the pad and its seat or by the pressure of the finger whether one key presses too hard or too lightly ; the regulating screw must be turned backward or forward until the two keys close together.

In the case of the doubly connected keys, where the F key works the G key and the B key together, first draw back the adjusting screw in the loop of the F key, and regulate the action of the G key, and then adjust the action of the B key.

To prove that all the keys on the middle or foot joint close perfectly, stop the lower end with a fine cork, and blow into the upper end, while all the keys are closed with the fingers; one can then determine whether or not the air leaks out. By strongly blowing in tobacco smoke it will be easily seen which key leaks. But, a more certain way is to draw out the air, after

## 58 THE FLUTE

which the fingers are removed; if then all the keys remain closed of themselves, it is a sure indication that no air leaks in.

Fig. 15 is a clamp made of steel wire with which the keys can be pressed upon the flute until the pads become perfectly seated.

### Fig. 15. Clamp for the Pads

Upon removing a pad which is still useful, one should designate its correct position in relation to the key stem by a mark, so that upon replacing it, it will come exactly into its former position.

I have given these explanations so minutely, because the certain speaking and pure quality of tone of a flute depends in a great measure upon a perfect key closing, and this again upon a good padding. Well made pads, which I have in stock, can easily be sent in letters as "samples without value."

### (d) The Springs

Of all metals, steel, undoubtedly, is the best for making springs. The genuine English darning or sewing needles of fine cast steel, well hardened, perfectly polished, which can be had in all required lengths

and thicknesses, the best fulfill all the requirements of good key springs.

Their preparation is quite simple. When it is necessary to replace a broken spring by a new one^

#### REPLACING SPRINGS

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select a needle of the proper length and of exactly the same thickness as the broken one, accurately fitting the hole in the spring post, so that it may be drawn in tight without being drawn through. When a proper needle is found, lay it on a thin piece of sheet iron, and hold it over an alcohol flame long enough for it to become uniformly of a beautiful blue or dark violet color. It thus loses its too great brittleness, and it can be easily bent as much as is necessary for obtaining the required tension, without danger of breaking. The needle may then be notched with a file at the right length and the superfluous end broken off. For this a fine sharp edged file is useful. The bending and inserting of the springs is accomplished by means of small pincers, Fig. 16.

Fig. 16. Pincers

If Steel springs break, it is almost always because of rust, which readily forms in damp air or from the perspiration of the fingers. A sudden breaking of a spring while playing is very disagreeable. To prevent this, I have sometimes made springs of hard-drawn gold wire, which cost only 4 Thalers extra; these are next to steel springs in elasticity, and for many years have proven themselves very durable.

### (e) The Cork in the Head Joint

Since the perfect tuning of the octaves depends upon the proper closing of the air column by the cork, it is necessary to smear it well with tallow each time it IS drawn out for wiping the head joint.

If the cork fits too tightly, it can be made a little smaller by rolling between two smooth surfaces such as a table top and a small board. Conversely the cork may be made shorter and consequently thicker by means of a cabinet maker's screw clamp.

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### Fig. 17. Gauge for Setting the Cork

That one may always place the cork exactly at the correct distance of 17 millimeters [about H inch] from the center of the mouth-hole, it is best to have a mark on the projecting end of the cork screw, and for verification to have also an accurate measuring stick such as is shown in Fig. 17.

## IX. TREATMENT OF THE FLUTE IN GENERAL

For a flute to remain in good condition as long as possible, it must be handled with care and cleanliness. Generally one has only himself to blame for the larger repairs required, for cracks in the wood or breaks in the mechanism are usually the result of carelessness and neglect of cleanliness. Such accidents are easily prevented. If the cork coverings of both joints of the middle part of a wood flute are well rubbed with pure tallow, they will then remain soft and will tightly close the joints against moisture; and the application of undue force when putting the parts together will become unnecessary. For the same reason, the draw tube of the head joint, and the socket tube on the lower end of the middle joint of a silver flute must always be covered with tallow.

The middle joint should never be grasped in the middle, but always on the upper end, to prevent injury to the key mechanism; and similarly the foot joint should be taken by the hand on the lower end.

The three pieces should be so put together that the flute may be held in a natural position. The mouth hole, the centers of the upper holes on the middle joint, and the axles of the foot keys should coincide in one straight line. The crutch should be inserted and so

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turned that the weight of the flute rests between the thumb and index finger of the left hand, then the movements of the fingers will be much freer than when the thumb is used for holding the flute. [In Fig. 9 a flute is shown with the crutch in position.]

[The translator agrees with Rockstro, who, in his treatise on "The Flute," says: "The crutch is a cumbersome and unsightly appendage, and is useless to those who have properly constructed flutes, and who know how to hold them. It seriously cramps the action of the left hand fingers, especially the thumb, while it is unproductive of a single advantage. Happily it is now almost obsolete."]

Further one should be certain that the flute is so held in the hand that no water can flow into the tone-holes, since moisture covered pads easily stick to the edges of the holes.

When the flute is layed down out of the hand, the crutch should be turned at right angles to the flute tube so that it will form a firm support for the flute when it rests upon a horizontal plane, the flute tube inclining downwards.

If a pad should become accidently wet and for this reason, or because of dirt, should stick, push a strip of printing paper under the pad and again draw it out while gently pressing down on the key. In this way the moisture and dirt will be rubbed off the smooth skin of the pad, and remain hanging on the rough surface of the paper.

If one takes the further slight trouble, each time

the flute is layed down, to wipe the perspiration of the

#### CARE OF FLUTE 63

fingers from the keys, the oxidation of the metal will be retarded, and the flute will remain clean and bright for a long time.

The most important matter in the care of flutes, especially of new wooden ones, is the wiping out of the tube. The warping out of shape of the wood, which alters the proportions of the bore, and causes most of the cracks, is the result of moisture, which collects in the flute tube during the blowing. This produces an unequal expansion ; the consequence of which is often the formation of superficial ridges, and frequently the complete bursting of the wood.

Consequently after each blowing the flute tube must be wiped perfectly clean and dry, for which purpose one had best use an old silk or fine linen handkerchief and a thin swab stick of the length of the middle joint. Fold one end of the corner of the cloth over the stick and push it through the flute, till the upper end can be taken hold of. Then by slowly drawing the cloth through, all the drops of the liquid will be taken up by the first part of the cloth while the following part which is yet dry will completely remove any remaining moisture.

Upon repeating this operation many times the bore will become polished, facilitating the full and easy production of tone; and this also makes it entirely superfluous to oil the flute tube, which is both disagreeable and injurious to the pads.

#### X. THE EMBOUCHURE

The open air column of a flute tube is exactly comparable with a stretched violin string. As the string is set into transverse vibrations by the bow and thus is made to sound, so the longitudinal vibrations of the air column of the flute are produced by the blowing.

Further, as the clear quality of tone of the violin

depends upon a proper manipulation of the bow, so also the pure flute tone depends upon the direction in which the air stream is blown against the edge of the mouth-hole.

Depending upon whether the air stream deviates more or less from the horizontal in a right angled direction, there originates from the fundamental tone of the flute tube, with all the holes closed, the so-called aliquot or harmonic overtones; e. g., for the fundamental tone Cg, the aliquot tones are C4, G4, C5, E5, G5, (Bsb). and Cg.

Each octave therefore requires a different direction of the air stream, and when the correct one is found, not merely will a fine quality of tone be brought out, but by increasing the force of the air blast, the tone may be brought to the greatest possible strength without any deterioration in quality or pitch.

#### THE EMOUCHURE 65

Indeed, by overblowing, each tone can be made to break over into higher tones, in which only a portion of the quantity of air is violently forced in the right direction. Not only through the air thus wasted, but also because of a poor embouchure, the tone loses in purity, and there is produced at the same time a buzzing and rushing noise.

#### XI. ON THE BLOWING OF NEW FLUTES

Experience teaches that all wood wind instruments are affected by the manner of blowing so that they become either better or worse with regard to the tones and their production. The tuning proportions remain unaltered, although the player can accustom himself to blow single tones higher or lower.

The reasons for this have never yet been satisfactorily explained. But it is known, that even after all swellings and deformations of the wood are removed from the flute tube as much as possible by the most careful swabbings. there still remains evident the influence of the manner of blowing. The best flute

loses an easy speech by overblowing and its bright clear quality of tone by a bad embouchure, and conversely gains in speech and tone by a correct handling and a good embouchure.

The formation of a good embouchure is therefore not only of the utmost importance for flute playing in general, but especially for the blowing of new flutes. Consequently a knowledge of the origin of the tone must be helpful.

m

Fig. 18.  
Bass Flute by Rudall, Carte & Co.

## XII. THE BASS FLUTE IN G

### (a) Its Musical Characteristics

In closing [in the original this section appeared at the end of the "Conclusion"] I feel that I ought to mention one of the most recently perfected, and therefore little known, developments of the flute, to the construction of which I was led by the great facility of vibration and easy speech of my silver flute in C; I refer to the "Alt-Flöte" in G [Bass Flute] which is pitched a major fourth below the flute in C.

[Fig. 18 shows the Bass Flute in G as made by Messrs. Rudall, Carte and Company.]

The long felt need for deeper, stronger, and at the same time more sonorous flute tones has not been satisfactorily provided for either by the former "Flute d'amour" or by the extension to the foot of a C flute, since the tones thus obtained are weak and uncertain, and their combination difficult and entirely unpracticable. There must be created an entirely new instrument in the family of flutes of deeper pitch, similar to the basset-horn and the English horn. [See page 8.]

In the calculation of the proportions of the air column, I gave preference to the deeper tones; the

speech is easy and certain, and lends itself to a surprisingly strong crescendo; hence the bass flute is suitable for playing in the largest room or in the salon.

## 68 THE FLUTE

I had made as early as 1847 ^^^ tubes giving an easy and certain speech for the tone E<sub>0</sub>

but the difficulties connected with the construction and playing led me to choose the tone G<sub>2</sub>

m

as the fundamental for my bass flute.

Because of the great facility of modulation of the full, sonorous tones of this flute, it is adapted to music in the song style, and for accompanying a soprano voice. A player will, after a very little practice, be in a position to bring out genre effects which are impossible upon the C flute.

[Very little music has ever been published for the bass flute; but there is a part for it in at least one modern symphony. Boehm arranged several solos for it, the manuscript of which seems to have been lost.]

### (b) Mechanism of the Bass Flute

Being made with G for its fundamental tone, there is required no alteration in the system of fingering, since the upper half of the key mechanism can be arranged to be played very conveniently by the left hand, through extensions of the axles, as shown in Fig. 19, and the lower half requires only slight alterations. [A clutch required to connect the A# and B keys is not shown in the original drawing.]

## MECHANISM OF THE BASS FLUTE

69

Ö3

\*~N

øf

Ö

ø1

fe

s

pq

«J

70 THE FLUTE

A very conveniently arranged "schleifklappe"  
[literally, "loop-key"], marked S and with a \* in

Fig. 19, may be opened by the thumb; it serves to give freer speech and greater purity of tone to the notes D<sub>4</sub>, E<sup>b</sup>, D<sub>5</sub>, D<sub>gft</sub>, E<sub>gb</sub> and A<sub>5</sub>.

The trill key, marked D and \*\* in Fig. 19, is a substitute for the long D trill key in all cases where this would be used on the C flute.

[The mechanism of the flute shown in Fig. 18 is arranged as shown in Fig. 19, except that there are trill keys for D and D#, to be played by the fingers of the right hand as on the ordinary C flute, and there is no schleif-key. This construction for the trill keys is the one now usually employed.]

### (c) Special Fingerings for the Bass Flute

All the fingerings of the C flute from C<sub>3</sub> to A<sub>5</sub> are applicable to the bass flute; but since the C<sub>3</sub> sounds as G<sub>0</sub>, of course the bass flute music must be written a fourth higher, that is, be transposed. [The tables of regular fingerings for the C flute are given on page 39.]

There follow two supplementary tables of fingerings; the first shows the application of the schleif-key, \*, Fig. 19; the second table indicates the special uses of the D trill key, \*\*, Fig. 19. [As mentioned above, the bass flute is usually constructed with trill keys placed as on the C flute, in which case the fingerings for the latter are directly applicable.]

### FINGERINGS FOR THE BASS FLUTE

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o • • •

O RO O O  
O

O • • •

SO»

O nh -& • •

O RO O O  
O

• P^O O O  
O

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g^jg?

&5»

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o • • •

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o • • •

CO»

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Part II – Flute-Playing

XIIL THE DEVELOPMENT OF TONE

Upon the supposition that the student has had elementary musical instruction relative to notes, time, keys, etc., such as may be found in any printed Flute Instructor (especially in that of Hugot and Wunderlich, Jos. Aibl, Munich) I will proceed to the flute playing itself, and shall begin with what I believe to be the essential requisite, the tone formation.

Although a good embouchure depends for the most part upon a normal formation of the lips and teeth, yet, if one does not have a proper appreciation of beautiful tone quality, that is if he does not have a proper tone sense, this, as well as a faulty embouchure, can be considerably improved by exercising in the following manner.

Since a gradual transition in all things is best, by passing from the easy to the more difficult, so one, in blowing a new flute, should not begin with the higher and lower tones which are more difficult to produce; but he should begin in the middle register, in which the tone C4 is best produced by a beginner.

When one has found the proper embouchure by which this tone can be clearly sounded in the delicate

Theojald Bokhm

Aged 76

At the time this book was written

#### DEVELOPMENT OF TONE

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piano, one should gradually, without raising the pitch, swell it to a forte, and then bring it back again to the faintest pianissimo.

When this is fully accomplished one passes in the following manner to the tone lying next. While sounding the C4 with a beautiful, clear, and pure tone, close the C key by a quick motion [of the thumb] ; yet without making alteration in the embouchure or in the force of the wind.

^Ä

The B thus obtained should remain unaltered in quality and purity of tone. Then sound the B alone,

and, after breathing again, proceed to B\).

Continuing in this way and with the least possible alteration of the embouchure, gradually, certainly and without exertion proceed to the lower tones and in a similar manner practice the tones from C4 upwards to the highest. Since each tone is always developed out

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of the preceding tone, which is as perfect as possible, all of the tones will remain equally perfect in quality, strength and purity.

As soon as one obtains a certainty in the embouchure, he should next practice all the major and minor scales; then thirds, fourths, fifths, sixths, sevenths, and octaves ; the embouchure will thus become accustomed to the making of increasing intervals, and soon one will be in a position to take the greatest skips with the proper embouchure, and consequently with certainty.

#### XIV. FINGER EXERCISES

Since the certain production of the tone depends not only upon the embouchure, but also upon a quick and smooth movement of the fingers, in this exercise all the tones should be slurred together, for in staccato playing one observes less easily whether all the fingers move up and down precisely together.

A portion of one's attention is always lost in reading notes, therefore, it is very important to play "by heart" as much as possible, so that the formation of the embouchure and tone may have the undivided attention. To do this will, of course, be difficult for the untrained musician. The best method for impressing upon the memory the proper sequence of tones in the scales and chords of all keys, is first to learn by heart the tones of one scale or one chord in only a single octave ; then one will soon learn to play the flute in all keys and through its entire compass. Furthermore I have come to the conclusion from my own practice as well as from my many years of experience as a teacher, that pupils advance most rapidly who take the trouble to practice patiently the complicated finger changes of a single difficult phrase until it can be played smoothly and clearly. One acquires in this way, so to speak, wealth which can be layed by, and which is always increasing by additions.

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When a short phrase is found difficult, it is evidently a waste of time to repeat the entire passage containing the "stumbling block" in the greater part of which one has already acquired facility ; one should practice a few troublesome notes till the difficult tone combination is mastered.

By such a judicious use of time I have brought many scholars in a year's practice to a thoroughly correct interpretation (execution) of a piece of music which others with far greater talent, but without patience and perseverance, would never acquire.

An answer is needed to the question which is so frequently put to me, "What and how should one first practice in learning my flute?" Notwithstanding this work makes no claim to the title of a Flute-School, yet

this is an appropriate place for the answer and the many interested flute players will welcome it.

#### XV. THE METHOD OF PRACTICING

Above all one should endeavor, at each time of beginning practicing, to secure a good embouchure, in the above described manner, for without a clear tone, nothing can be well and beautifully played. The tone is the voice without which one cannot even begin to sing.

When the embouchure has become good and certain, one should study the scales and chords in all the keys, for these are the foundation of all passages, and when one has once learned to play them with precise finger movements (which can be easily determined by the ear) all the other tone figures will be quickly and easily disposed of.

As has been said, it is only a waste of time to repeat anything that can already be played without stumbling. Difficult finger movements, on the contrary, must be gone over very slowly at first, so that in the slurred tone combinations no interpolated tones are audible, and no lack of purity is noticeable. Especially one must train the fingers to a perfectly smooth movement by the trill exercises, so that no one tone predominates; and that no bleating or so-called "bocks-triller" is produced.

To secure this smoothness, there must be no perceptible cramping tension of the muscles, in either

#### yS FLUTE-PLAYING

the hand or arm, this cramping- results from an entirely unnecessary expenditure of force.

If one only forms the idea that a thing is not difficult, it becomes much easier.

Further, many flute players have the bad habit of raising the fingers not only much too high, but also to unequal heights, whereby complicated finger movements become unnecessarily difficult; since when

several keys are closed at the same time, if one finger must move much farther than another, it is perfectly evident that they cannot reach the end at the same time.

The raising of the fingers too high has another disadvantage, since in rapidly closing the keys a very audible and disagreeable clap or rattle is produced, and at the same time the key receives a blow and the mechanism a reaction which clearly work disadvantageously to them. On the contrary, if the fingers are held directly over the keys a forcible closing of them will be nearly or wholly inaudible, and there will be produced only a pressure without rebound.

The fingers therefore should be held at equal heights, and no higher than is necessary above the keys. To secure this, and especially as most players do not realize how high they have raised their fingers, I advise all my pupils, when practicing the scales, to stand before a mirror. They are then in a position to see not only the finger movements and the whole manner of holding the flute, but also to detect many bad habits, such as distortion of the features, and unnecessary movements of the head, arms and body.

#### METHOD OF PRACTICING

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If one cannot express his feeling's through the style of tone, he surely is not in a position to do so by head or body movements. A calm, firm attitude certainly presents a much more pleasing appearance to the hearer than visible exertions, or affected, sentimental movements.

Since bad habits are very difficult to overcome, they ought to be removed in their beginnings ; it is very short sighted to economize in the beginning, for in the end the best teacher is also the cheapest. It is impossible for everyone to find a good teacher, and in all the flute-schools known to me the methods of style are treated in a very superficial manner ; therefore, I believe that my views upon this subject, founded upon many

years of experience as an artist and teacher, should be given.

#### XVI. MUSICAL INTERPRETATION

He who, like myself, has been fortunate enough to have heard, for more than fifty years, all the greatest singers and songstresses of the time, will never forget the names of Brizzi, Sessi, Catalani, Velluti, Lablache, Tamburini, Rubini, Malibran, Pasta, etc. It fills me with joy to remember their artistic and splendid performances ; they have all come forth from the good old Italian school of song, which today, as in the past hundred years, gives the foundation for a good voice formation, and leads to a correct understanding of style, which is an essential for the instrumentalist as well as for the singer.

The interpretation of a piece of music should evidently give to the hearer what the composer has endeavored to express in notes. The player himself must therefore, in order to be intelligible, first clearly comprehend the sense and spirit of the composition.

But the means which the composer has at hand are not always sufficient to clearly convey his ideas. All the customary designations of the tempo from largo to prestissimo being without metronomic determinations give rather indefinite ideas; and the articulations, accents, and nuances of the tone strength, especially in older or carelessly copied music, are designated at the best in a very faulty way and often not at

#### MUSICAL INTERPRETATION 81

all. Much is left therefore to the discretion and individual comprehension of the performer, in which respects, as is known, even thorough musicians will differ considerably.

In the orchestra, naturally the view of the director is followed and the flutist who plays each note according to the dictated directions, clearly, with a good and pure tone, has accomplished much, and his playing is at all events correct.

In solo playing, on the other hand, where the player himself appears, the overcoming of technical difficulties is mainly accomplished by a surprising amount of practice, after which the genuine artist should endeavor to bring out a definite expression of feeling. It is much easier to win applause by a brilliant execution, than to reach the hearts of the hearers through a cantabile.

For example, to play well an adagio with all the possible colorature, the player must not only be a perfect master of his instrument, but must also have the power to transform his tones, as it were, into words, by which he will be able to give his feelings a clear expression. He must learn to sing upon his instrument ; in singing one is easily led to a correct interpretation by the words of the text, for a clear idea of the meaning is connected with the words through the feelings expressed in tone.

If the composer under the influence of the words of the poem has been enabled to express his feelings in tone, and to form his melodies upon the laws of rhythm and declamation, so also the thoughtful instru-

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mentalist can perceive the correct interpretation of the music of an aria or song in its text.

He will learn by the study of good song music when and why a note should be played staccato, or be slurred with the next following; and when an accent or a crescendo or diminuendo in the tone strength, is necessary to bestow upon the music an expression corresponding to the words ; and when a breath can be taken without breaking the correct declamation.

The text will clearly show him the phrases and will indicate to him the points for which the full strength of the tone must be saved, for producing the greatest effects, as is done by the points of highest light in a good painting.

The following examples will serve as a clearer explanation of what has been said, as well as to explain the portamento di voce which is indispensable to a good style of cantabile.

Since it is only possible to indicate the declamation or correct expression of the words of a text on an instalment by means of articulation, that is by striking the notes according to the meaning or syllable-beginnings of the words, it is important to learn the necessary art of tonguing and its proper application. This is indicated in three different ways, namely a

short staccato by little lines \ \ ' \ t] ' ' ^^^^ staccato

by points I L L I j J ^^^^ ^'^ entirely smooth staccato

by points over which there is a slur ( f f f ) j indi-

#### TONGUING

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eating that the tone is to have merely a new impulse, but that the air stream is not to be interrupted.

This tonguing should sound as softly as the second syllable "de" [^e] for example, in speaking the word "Beide" [hi-te] ; which serves very satisfactorily for the making of separate syllables ; and in many cases the expression can be further increased, as is indicated in the following example.

Larghett0. fSingiUmmt.J

Zanberflöte.

^Ö^^^^^^

Mozart.

DiessBildniss ist bezaubernd schön, wie noch kein Au-ge je ge - sehnlich fühles, ich föhl es, Tnedies  
s

[The musical illustrations have been photographically reproduced from the German edition. The line above the words is the music for the voice, while the line below indicates the interpretation for the flute.]

The correct articulation follows here of itself from the declamation of the words.

By means of the soft tonguing of the four notes K\), D, C, and B\) of the first bar. as well as the notes D, C, B^ and Aj^ of the third bar, there is given to the words "ist bezaubernd schön," and "kein Auge je gesehn," considerably more expression than if they were entirely slurred together. The breathing places are indicated thus : ^

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#### FLUTE-PLAYING

Further it is evident that it is not allowable to slur any note over to the first note of the next measure, since it almost always happens that the note falling in the so-called strong part of the measure must be tongued, in order that the word depending upon it may receive its proper accent. The slurring of a note to the following measure is always a fault, unless it is justified for some special reason, as in dance music or comic songs, where it may be used to produce a piquant or bizarre effect. For example :

But in song music this tying over from the weak to the strong beat of a measure is allowable only when employed as syncopation, as in canon or fugue, to bring out an increased expression. For example in the following illustration where the word "nur" is repeated in the third measure, the anticipation of the E by a quarter note constitutes a syncopation, by means of which the effect is increased.

L«rgo.

(Siagttimme.)

Ads „Joseph“,

Nurmei-ne Kinder lass glackUch stete sain, Durmei-oe Kio-der lass ElAckUchstetiseill  
Baodsheu-reiumeB en-fans, euuse mApri^Mt Bends 1^ heureax.reodsLn beu ^ r«oz.  
(Flöte.) -

The following example will furnish, through a reading of the text, a clear idea of the rhythmic and declamatory significance of each note.

#### MUSICAL INTERPRETATION

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The methods of interpretation which I have here given for playing on the flute, will serve as guides by which anyone may learn to correctly judge why and in what manner a note should be tongued or intoned, so that it shall give the sense and expression of the word for which it is a substitute, or whether it should

be considered merely as a syllable without significance, and should therefore be slurred together with other notes.

Upon the repetition of a strophe, on the contrary, where the theme would become somewhat monotonous in the absence of words, the player may be allowed to take some license, and add little ornaments in suitable places; especially in bright and light melodies. In the last of the following songs, "Das Fischer-mädchen," for example, a heightening of the expression will result, if the ornaments are performed not heavily, but lightly and gracefully.

Mäufig. (Sütgtttamt,)

Der Lindenbaum.

Am BroiioeD vor dem Thore. da steht eiD Lin-deDbaum, ich träämtio eei-aem Schatten so  
(ffctt.)

man-chen sfla-aea Traom: ich schaittin sei - ae- Ria- de so man-ehes lie -be Wort,' ei

zog in Freud' und Lei - de

ihm mich im - mer fort

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FLUTE-PLAYING

In the preceding song the triplets, and also the sixteenth notes of the third and seventh bars of the following, may be slurred ; however, in my opinion, a soft tonguing gives a more definite effect.

Ziemlich langsam. {SingaUmme.}

Trockene Blumen.

seht ihr al • le miidi ao so weh, als ob ihr waestet, wie mir ge-Bcheb?ibrBlamleüi alle, wie

welk, wie bUeel ihr Blfimlein alle, wo - von so nass?

Massig {SiagattTiime.}

Ständchen.

Lei-se Se- hen mei-ne Lie-der durch die Nacht zu dir, in den Stil- lea paia hei - oie • dar

(Flilt.)

Liebchen.kommzuniir. Flüstemschlanke Wipfel nu-schea in des Mon-deB Licht, in desMon-des

Licht; des Ver - rä - thers feindlich Lauschen fürchte Hol - de nicht, forchte Hol - de nicht.

The triplets may also be slurred together, in the above song.

Etwas g-e&cbwind. {Singstitime.}

#### COLORATURES

Das FiBchermädchen.

87

The great wealth of beautiful German songs of Mozart, Beethoven, Schubert, Mendelssohn and others are almost inexhaustible sources of studies for the formation of a correct interpretation and a good style.

From the words of the poems of the popular songs of other nations, such as Scottish, Irish, Swedish and Slavish, one may also learn a good interpretation.

One should begin with songs which are simple but full of expression in word and melody, then one will soon learn to comprehend compositions, which, as Beethoven's "Adelaide," are written in the highest dramatic style, and form a transition to the arias for the inteq^retation of which a knowledge of all the arts of ornamentation and colorature is necessary.

All coloratures may be considered a diversification of a single note, whose time value is partially or wholly consumed in executing the ornaments.

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#### FLUTE-PLAYING

The simplest ornament is the accented appoggiatura which moves either upwards or downwards, and is designated by a small note; and for equally divided notes it takes one-half of the time value of the principal note, and for unequal division it takes one-third.

A0flfuiUTlflg.

[The musical ornaments are first given "as written," and then "as played" ; in some instances the name or interpretation seems to be incorrect.]

The double appoggiatura, consisting of two or three small notes, is to be treated in a similar manner. This may form a tripet, as in the examples :

The double appoggiatura is to be distinguished from the "schneller" or half-mordent, in which the first of the two small notes is always the same as the principal note; for example:

The true mordent (gruppetto) is a group of three or four small notes which move within the compass of a minor third, and consists, both in ascending and descending, of a note first above and then below the given note. For example :

THE TRILL

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A very effective, and at the same time the most difficult vocal ornament is the trill, a thoroughly good execution of which is, at the present time, unfortunately, very rarely heard. The trill consists in the alternation of two adjacent tones, a major or a minor second apart, which are to be smoothly and rapidly repeated. Following the best old Italian school of

song, the trill should commence upon the principal note, and not upon the auxiliary note; the two notes must have equal tone strength, and exactly equal time value, and the alternation should be slower in Adagio, and more rapid in Allegro. For a final cadence, or a fermata, it should gradually increase in speed, and there should be a swelling out and a diminishing of the tone strength. Further, every trill must end with a resolution which is formed of the principal note preceded by the next lower note. The "Pralltriller" [inverted mordent] is the only exception to this rule. For a cadence trill the ending may have a variety of forms, according to the taste of the performer. .

tr tr tr tr

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#### FLUTE-PLAYING

According to my idea, all trills not resting upon the note of the harmony, such as the last preceding mordent trills, and trills consisting in the multiplication of an appoggiatura, should begin with the auxiliary note, and proceed by means of a final resolution.

All trills must begin slowly, and very gradually become more rapid, a perfect equality of the tones being- maintained throughout, and the production of a so-called bleating or "bockstriller" must be avoided.

Equally useful are the ornaments produced by runs, which are also developed by the diversification of a fundamental tone and which must therefore be played exactly within the time and in the manner of expression of this note ; either with equal tone value (tenuto) or with increasing strength (crescendo) or diminishing strength (diminuendo). For example:

Since the time of Mozart, especially by Rossini, all the vocal ornaments have been accurately written out by composers, hence one will find in operas and concert arias a large selection of tasteful and effective coloratures, which will serve as models for practice.

#### ARTS OF COLOR ATURE gr

Many arias also contain the most beautiful melodies for the study of cantabile which in aesthetic respects will remain the best examples, and for the reading of which the flute player must have all the qualifications which characterize the genuine artist. These qualifications are an intelligent comprehension' of the composition, a deep feeling and a cultivated taste, correctly timed breathing, and a perfectly formed' tone, for without these a good interpretation of a cantabile with portamento (gliding voice) is impossible.

Although the proper portamento di voce, namely the gliding over from one tone to another while speaking two different syllables, is adapted to the human voice alone, and consequently seldom seems good and appropriate on string instruments, yet it is sometimes desired to imitate it upon wind instruments with tone holes. On account of defective execution, however, the effect is often repulsive and suggests cat music on the roof, rather than a beautifully sung cantilena.

The significance, often misunderstood, of the word portamento, seems to me to consist in a development of the legato derived from the Italian cantare legato in which all the intermediate tones are delicately and smoothly connected together, like a series of pearls by a connecting thread, the latter being figuratively represented by the air stream. For example :

The following extract from the aria of Donna Anna in Mozart's "Don Juan" serves as a combination

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## FLUTE-PLAYING

of the above described song-studies, since the cantabile of the Larghetto ends with simple runs and mordent ornaments, and the Allegretto contains mordent trills, roulades, and a closing trill, and has practically all of the arts of colorature.

In the lower line, designed to be played upon the flute, all of the legato places are designated by skir marks, the moderate articulations by points and the sharply tongued notes by lines. The places where breath should be taken are designated by large breathing signs, and the places where it may be taken if necessary by small signs. [In the original edition there are no staccatissimo lines, and the breathing signs are all alike.] The explanation of the trills which occur has already been given above.

Larghetto. ( Singstmme. )

=t=1

Don Juan.

, f 1 ^., K

1 , J 1 f

Mozart.

Nod - mi dir, bei

-^\_^

dol mi- or

che son i  
f

• era • del eon - te

B-^ Saif-g^^lj' i rJlfep:»^4r-fHr1-^lia ^>IJ-H

\*> meztavcc,. ' ^-^ä ""^

;^

K. ^

tenuto.

"

ARTS OF COLORATURE

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## XVII. CONCLUSION

I BELIEVE that I have now pointed out the surest way in which one may learn a correct and elegant style of playing, so that one may be prepared to delight himself and others not only with difficult compositions, but also with simple and beautifully played songs.

Moreover, attention to my instructions will lead to a correct technical execution ; for this there has been

printed as a supplement to this work and published by Jos. Aibl in Munich, "12 Uebungssticke in alien Tonarten," forming a transition to the following earlier composed studies in which are to be found pretty nearly all the practicable difficulties for the flute. [The "12 Practice Pieces" are published by G. Schirmer. New York, in the "Library of Musical Classics."]

1. 1^tudes pour egaliser le doigte dans toutes les

gammes, op. 15 ; Falter & Sohn, Munich ; Rudall, Carte & Co., London.

2. 24 Caprices-E^tudes, op, 26; B. Schott's

Söhne, Mainz; Richault, Paris; Rudall, Carte & .Co., London.

3. 24 ]Eitudes pour la Flute seule ou avec accom-

pagnement du Piano, op. 37; B. Schott's

Söhne, Mainz.

[As indicating the extent to which Boehm himself achieved the style of playing which he advocates, two extracts from criticisms of his concert performances are given : "His playing shows a tender, elegiac senti-

BOEHM'S LAST COMPOSITION

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ment, a beautiful, romantic longing; his singing upon his instrument is inspired by the deepest feeling. His mastership in seizing all nauences, the melancholy pathos of his style, wins him the first place among the flutists of Europe. One hesitates to breathe for fear the tenderness and soulfulness of the blended tones will be disturbed and the magic spell will be broken." "The playing of Herr Boehm is firm, especially pure and

technically efficient, with a beautiful, tender, and yet very full tone. The very difficult task in Drouet's 'Variations' he gave with so much finish and good taste that we owe the artist our thanks for an evening full of enjoyment."]

[Boehm wrote over sixty compositions for the flute, including original pieces in various styles, and arrangements of the classics, with both piano and orchestral accompaniments. One of his best compositions is also his last, the "E<sup>^</sup>legie," opus 47. Schafhäütl, in his "Life of Boehm," speaks thus of it : "His swan-song bears the very characteristic title of 'E<sup>^</sup>legie.' It is written in the key of A<sup>^</sup> major; a sweet melancholy rises through forty bars to a bitter lamentation, only to sink back by degrees to a peaceful resignation. It is the aged man, who, already ailing in his eighty-seventh year, once said : I would that I might yet live to the ninetieth year; but as God wills.' The E<sup>^</sup>legie is composed for full orchestra. The orchestra raises the composition to a work of true magnificence, speaking here and there, in a most effective way, what the singing flute-voice only indicates." Boehm died in 1881,, in his eighty-eighth year.]

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