HINTS ON THE FINGERING

OF THE

BOEHM FLUTE

BY

Victor C. MAHILLON,

Musical Instrument maker, Corresponding Member of the St Cecilia Academy, Rome and of the Royal Academy of Florence; Sangita upadhyaya of the Academy of Calcutta; Curator of the Museum of the Royal Conservatory of Music, Brussels.

ENT. STA. HALL. PRICE, NETT : £ 0 1 6

182 WARDOUR STREET,
(FOUR DOORS FROM OXFORD STREET)
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C. MAHILLON and Co

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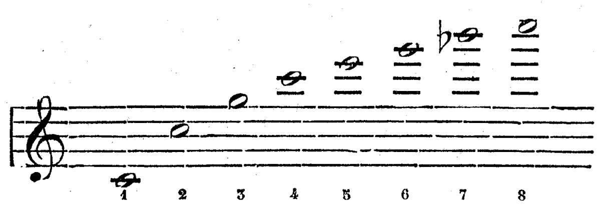
The fingering of the Bœhm Flute is based on the progressive shortening of the column of air, by the aid of the side-holes in the tube, and on the property, **common to all wind instruments,** of effecting, by the gradual augmentation of the wind pressure, the production of a series of sounds, called **harmonics,** of which the relative vibration corresponds with the arithmetical series 1, 2, 3, 4, etc., and the formation of which is due to the division of the column of air into 1, 2, 3, 4, etc., equal or aliquot parts. Thus, when all the side holes are closed, the sounds



may very easily be produced. (The figures under the staff indicate : 1. The order of succession of the sounds; 2, the relative vibration existing between them; and, 3, the division of the column of air into $\frac{1}{1}$, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc.). In playing wind instruments, the production of the higher harmonics is the more easily accomplished the longer the tube; the sound 16 can be easily produced on an E flat Horn, whilst it is only with difficulty that a good performer can give the sound 8 on an E flat Soprano Cornet, the length of the first of these instruments being four times that of the second. The tube of a Flute is much shorter than that of the E flat Soprano Cornet, but the vibratory motion of the column of air is more easily produced by the special structure of the mouthpiece of a Flute, and the equal division of this column obtained with greater facility; to produce, however, the harmonics with unerring accuracy, certain peculiarities have to be introduced into the fingering of the instrument.

These peculiarities give rise to the rules for the fingering of the third octave, which have been discovered by a series of practical experiments. We propose to explain the said rules, with special reference to the Bœhm Flute, as being that which is at present in most general use; what we shall say of it will explain the theory of fingering for the instruments on the old system, sufficiently to render it clearly intelligible.

Too many instrumental performers entertain only a very small liking for theoretical study, and this indifference strikes them as justified by the results obtained without the help of acoustic science. It is evident that an instrument can be admirably played without the performer's ever having troubled himself with the principle of its construction; but, in this case, there is the risk of his repeating, and propagating in his turn, the innumerable errors and prejudices which spring from purely mechanical work. Is this a reason for continuing eternally in the same path? We do not think so, and we hope to convince those instrumentalists who will kindly bestow a little attention on these hints; and those who are not blinded by preconceived notions will see not only that theory substitutes intelligent for mechanical work, but that, on many occasions, it greatly assists practice itself. Such persons will join us in the hope that, at no far distant date, the teaching of theory will be rendered obligatory in all our Music Schools, and that first-class prizes will be given only to competitors who, in addition to ordinary accomplishments, possess a sufficient knowledge of theory.

Before proceeding further with our subject, it will be advisable to define precisely the nature of wind instruments. A wind instrument is an instrument in which the air in vibration is the sounding body. The tube serves merely to determine the form of the column of air. Given two tubes constructed of different materials, the sound, as well as its qualities (pitch, intensity and timbre) will be the same, if the columns of air are of the same form, and the sides enclosing them possess the same amount of smoothness and rigidity.

« **To blow in the instrument** » is an expression in common use, but it is incorrect. To produce no sound, it is sufficient **to blow in the tube**, as all beginners do. To produce the vibratory motion of the column of air, and impress on it regular pulsations by the effect of the wind on the mouthpiece, such is the action of an educated performer.

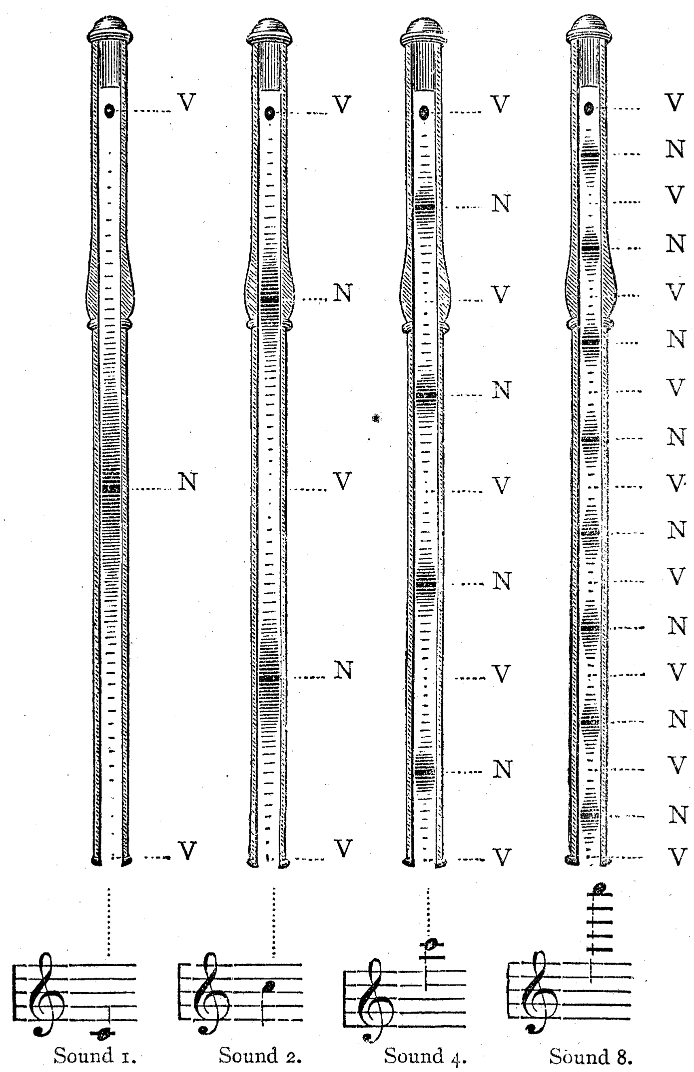
It can be easily proved, by a very simple experiment, that the air does not play the part generally attributed to it in the production of the sound. The experiment in question is as follows : Close all the side-holes of a Flute, or any other instrument bored laterally; place a lighted match at the end opposite the mouthpiece. **Blow** in the instrument, and the match will go out. If, however, after opening one of the lateral holes, and holding a lighted match about half an inch from it, we **blow**, the flame will waver, but not go out. Why? Because the air, following the direction of the axis of the tube, will escape only feebly through this opening bored at a right angle. But, if, instead of **blowing** in the instrument, we make the column of air vibrate in such a manner as to produce a fundamental sound, the match placed before the open side-hole will go out, because the air will then be affected by a vibrating motion, which the flame will not be able to resist. On the contrary, if the match is placed at the end of the tube, the flame will remain motionless, when a side-hole is open. It is not, therefore, the transfer of the air, but the vibratory motion imparted to it, which produces the sound.

We have said that the column of air, by a gradually increasing wind pressure, is divided into parts which grow smaller and smaller; we will now endeavour to explain this phenomenon in connection with flute-playing.

The Flute belongs to the kind of tubes classed under the name of open pipes, in which the column of air, set in motion by the performer, forms at each extremity a ventral segment or loop, where the air has its maximum of velocity with no pressure variation.

Figure 1 represents a flute tube, vibrating so as to produce the sound 1, or fundamental sound. The letters V indicate the place of the ventral segments; the letter N marks the place of the nodes. The nodes are the places of maximum pressure variation. When the column of air vibrates, the motion is communicated successively to every individual portion on each side of the node alternatively, backwards and forwards; in consequence of this, condensation takes place on one side of the node and rarefaction on the other. The sound 1 is called the fundamental note, because it is produced by the column of air vibrating in its most simple state (Fig. 1); that is to say, with a loop at each extremity of the tube and a node in the centre. The sound 2, or first harmonic, is the result of the division of the column of air into twice the number of parts, as shown in Fig. 2; the air must vibrate in it at double the rate of speed; it is necessary, therefore, that increased pressure should be applied by the performer; the sound springs up to the octave of the fundamental note. On the performer's still further increasing the pressure of the air, the sound 3, or second harmonic, is obtained, which is a division of the tube into 3 times the number of parts, causing three times the vibrating velocity, and consequently producing a sound which is found to be in the ratio of 3 to 2, or vibrating ratio of the fifth, to the sound 2; if the pressure is still more increased, the tube is divided into four times as many parts, causing four times the number of vibrations, and, consequently producing a sound which is the octave of the first harmonic, (Fig. 3), etc., etc.

fig. 1. fig. 2. fig. 3. fig. 4.



Sound 1. Sound 2. Sound 4. Sound 8.

In producing harmonic sounds, the division of the tube naturally produces a difference in the position of the nodes and loops. It is evident that, taking the case of the fundamental tone, or sound 1, if we make an opening in the centre of the tube, where the node is, the air in the interior, communicating with the air outside, takes the density of the latter; while the node necessarily disappears and makes way for a loop; the column of air is thus divided and the note springs up to the octave (Fig. 2).

If the opening is made one third down the length of the tube from the top, the sound springs up to the twelfth.

Thus, the sound 4 is obtained by making the opening a fourth down the tube (Fig. 3); the sound 8, by making the opening an eighth down the tube, (Fig. 4), etc.

It is almost superfluous to remark that if the opening of a hole at the point where a node is formed forces the column of air to modify its division and produce another harmonic, the opening of a hole at a point where a loop is formed produces no modification in the sound. Thus, in the case of the 1^{st} partial (fig. 2), a side-hole may be made at the point V of the centre, without any alteration in the height of the sound; the opening simply facilitates the division of the column of air.

The preceding principles being well understood, the reader will have no difficulty in comprehending the necessity of the fingering employed to produce the series of sounds which determine the compass of the flute.

This compass is formed of other sounds besides the harmonics of the principal tube. By the help of the lateral holes, the column of air can be shortened by determined quantities and thus produce a whole series of fundamental tones.

Figure 5 represents a Boehm flute of cylindric bore with the chromatic scale of the fundamental tones obtained by the successive openings of the lateral holes. It is absolutely the same as if the performer had fourteen tubes of different lengths, each one furnishing, in addition to the fundamental tone, the series of harmonics resulting from the division of their respective columns of air. Only, as the tubes become shorter and shorter, the upper harmonics are produced by a division growing smaller and smaller, and consequently the emission becomes more and more difficult.

It may be useful for the performer to know that the length of the instrument and the position of the lateral holes are determined by fixed laws. The law as to length, although giving only approximate results, is of sufficient interest to warrant our stopping an instant to consider it.

Sound travels about **340 mètres** a second; this rate of speed increases with the temperature, and this explains why the instrument, in proportion as its temperature increases, requires a longer tube than that necessary to produce a sound of equal height with a lower temperature.

The Simple Wave is the distance which sound travels during a single vibration of the body producing it; this wave, being double the distance of a loop to a node, corresponds with the length of the tube giving the fundamental tone. In order to

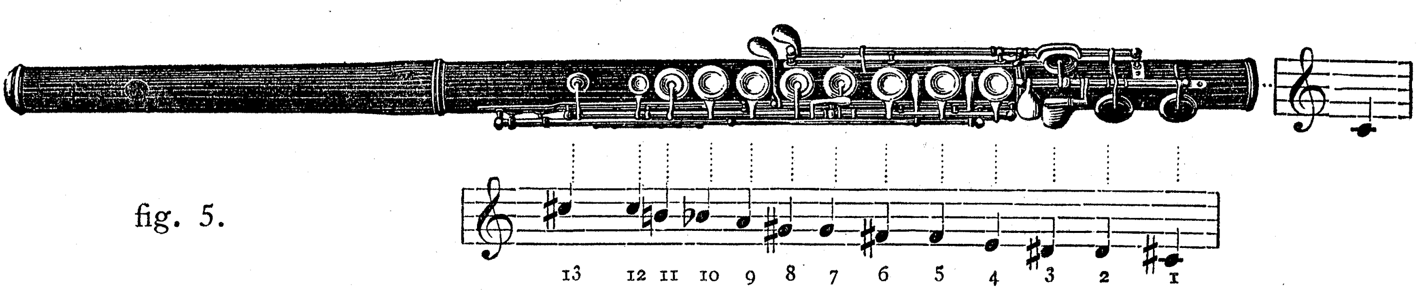


fig. 5.

know, approximately, the length of the tube, it will suffice, then, to know that of the wave. The length of the simple wave of sound making a vibration in a second would be **340 mètres**; if the sound were produced by two single vibrations, the simple wave would be $\frac{340}{2}$. The length of the wave of any sound is obtained, consequently, by dividing **340 mètres**, the speed of the sound, by the number of vibrations. The lower C, or normal pitch is produced by 517.2 single vibrations. To obtain the length of the wave, and consequently the length of the tube, necessary to produce it, divide **340 mètres** by **517.2**, and the quotient **0^m,657** is the desired length. To know the theoretical position of C♯, divide **340** by **548** single vibrations, and the process will give the length as **0^m,62.**

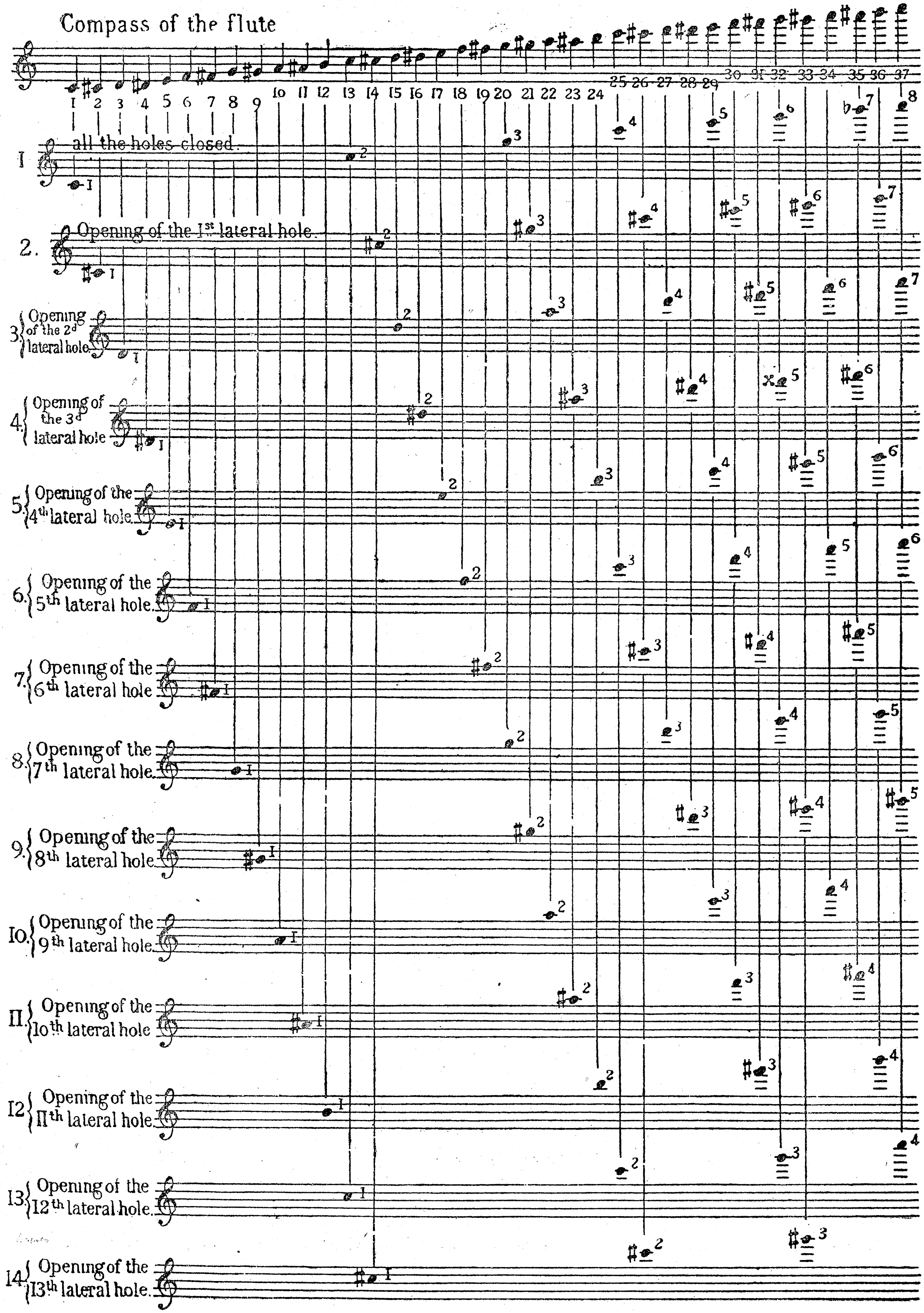
We have said that the laws of length give only approximate results. It will suffice, however, to compare these figures with the real length of the flute and the position of its lateral holes, in order to convince our readers that, in this instance, theory does not agree with practice; and the divergency exists not only for the tubes of flutes, but for columns of air in general. In 1860, M. Cavaillé-Coll, the celebrated organ-builder, presented to the Academy of Science, of Paris, a formula by which the length of an organ tube could be calculated exactly. This formula as applied to cylindrical tubes is : $L = \frac{V}{N} - D\frac{5}{3}$, in which L represents the length of the tube; V, the velocity of the sound; N, the number of single vibrations ; and D, the diameter. This formula is not applicable to the calculation of the length of a flute. The mouth-hole of this instrument, from its lateral position on the tube and from the fact of its diameter being less than that of the section of the tube, lowers the sound more than the mouth of organ pipes do; in consequence of this conformation of the mouth-hole, the tube of the flute is classed amongst those known as **partially stopped pipes.** Moreover, the part of the flute between the mouth-hole and the plug used to close the upper extremity of the tube, acting as a **stopped pipe** (1) should count as double in estimating the total length of the flute. The space between the plug and the middle of the mouth-hole is about **0^m,017.** Under these conditions it is difficult to calculate with absolute precision the length of the flute.

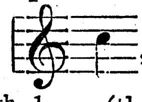
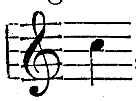
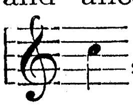
The calculation of the exact position of the lateral holes is more complicated still, and to explain how it is effected would take us far from our subject. The practical process is, moreover, of little interest to musicians. Those of our readers who are desirous of learning something of this important branch of the maker's business we refer to the special works on the subject (2).

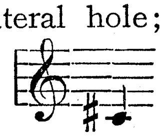
The annexed table indicates the order of succession of the harmonics of each of the 14 fundamental sounds, applied to the scale of the flute :

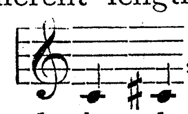
(1) The stopped pipe is half the length of the open pipe giving the same sound.

(2) Dr Von Shafhäutl, under the pseudonym of C. E. Pellison, has written an interesting treatise on this important subject : *Theorie gedeckter cylindrischer und könischer Pfeifen und der Querflöten.* Halle bei Ed. Anton, 1833. — *Ueber den Flötenbau und die neuesten Verbesserungen desselben.* Mayence, B. Schott's Sons, 1877. — *An Essay on the Construction of Flutes,* originally written in 1847 by Theobald Boehm and now first published by W. J. Broadwood. London, Rudall, Carte & Co, 1882. — *Éléments d'acoustique musicale et instrumentale,* par V. C. Mahillon. Brussels, C. Mahillon, 1874 ; London, C. Mahillon & Co.


Compass of the flute
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
I all the holes closed.
2. Opening of the 1st lateral hole.
3. Opening of the 2d lateral hole.
4. Opening of the 3d lateral hole
5. Opening of the 4th lateral hole.
6. Opening of the 5th lateral hole.
7. Opening of the 6th lateral hole
8. Opening of the 7th lateral hole.
9. Opening of the 8th lateral hole.
10. Opening of the 9th lateral hole.
11. Opening of the 10th lateral hole
12. Opening of the 11th lateral hole.
13. Opening of the 12th lateral hole.
14. Opening of the 13th lateral hole.

The inspection of this table shows that the first 12 sounds of the chromatic scale,  to , have only one possible fingering, that this fingering is that of the fundamental tone of the principal tube and of the first eleven lateral holes. But the thirteenth sound of the scale, , can be produced in two different ways : 1st by the fundamental tone of the 12th key (the fingering generally employed), or by the help of the 1st partial (1) of the tube, vibrating with all the lateral holes closed. We have said that the production of harmonics on the flute, gains in intensity and facility by our aiding the division of the tube by the opening of a hole at the place of a loop, and we have seen that in the production of the 1st partial, the first loop, not including that at the extremity of the tube, is half-way down the column of air. To give , 1st partial, open, then, the tube at this place : the 12th lateral hole, the opening of which gives , a fundamental tone, corresponds, also, exactly to the position of the loop; take, then, the fingering of , a fundamental tone, and uncover only the 12th lateral hole, closed by the thumb of the left hand, and , the 1st partial, will come out clearly.

There are two modes of fingering for  : the first is that of the fundamental tone of the 13th lateral hole; the second, that of the 1st partial or 1st harmonic of the fundamental tone,  : the emission of which will be facilitated by opening the 12th lateral hole.

It follows from what precedes that an opening may serve to cause the division of two columns of air of different lengths; thus the opening of the 12th lateral hole causes the two fundamentals, , to jump to their respective octave. It is not necessary for the opening producing the formation of a loop to be made exactly in the place assigned it in theory; it is sufficient if the opening be near enough to hinder the presence of a node at the place; this result is attained by bringing the air in the interior of the flute into communication with the air outside, such communication hindering the variations of density and pressure which characterize the nodes.

The production of the 1st partial would be equally facilitated by opening the 13th lateral hole; but this harmonic would be too sharp, because the position of the lateral hole is obviously too far above the point which divides in two equal parts the length of the tube necessary for the fundamental.

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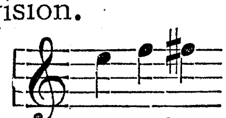
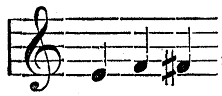
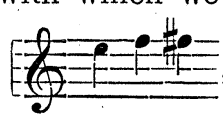
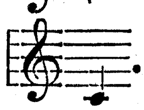
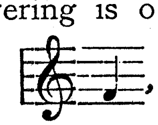
(1) By first, second, third, partials or harmonics, etc., are meant the second, third, fourth, etc. sounds of the harmonic scale, the fundamental being always distinguished by the number 1.

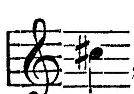
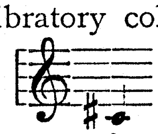
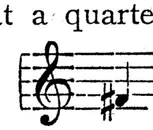
There is, according to our table, only one fingering for the notes , first harmonics of the fundamentals ; they both come out by increased breath-pressure, but their production is much facilitated by the opening of the 13th hole, which gives the fundamental . The opening of this hole serves not only to establish the loop necessary for the production of these notes , but is, also, useful, as we shall see later on, for the production of other harmonics. This double use necessitates this hole being placed in a medium position, favourable to the formation of different loops, and this is the reason why this key only is placed in an irregular position, compared to the positions of the other lateral holes. It is noticed, then, that on the Boehm flute, cylindrical bore, the lateral holes are not only of equal diameter, but that their position along the tube is determined by a geometrical division.

The notes  have only one fingering. These are the 1st partials of the respective fundamentals , and are produced by an increased breath-pressure. But, besides the fundamental tones produced by the principal tube and the opening of the 13 lateral holes, marked in the preceding table, the Boehm flute has the power of giving two supplementary fundamental tones, , by the help of two holes placed above that of , and closed by two keys, the first  being worked by the middle-finger, and the 2nd, , by the ring-finger, of the right hand. These fundamental tones are scarcely ever used, except for trilling certain notes, or for causing the formation of the loops facilitating the emission of other notes with which we shall meet with later on. It should be noticed how much easier the notes , first harmonics, are rendered by adding to the fingering of their fundamentals, for the first, the key of , for the second and third, the key of .

Our table indicates two fingerings for : the first answers to the 2nd partial of the fundamental , the second, to the 1st harmonic of the fundamental . The first fingering would require in order to facilitate the emission, an opening in the 1st third of the length of the tube between the lower orifice of the instrument and the mouth-hole; but, as there is no lateral hole here, this fingering has been rejected in practice. The 2nd fingering would be facilitated by an opening half-way between the part of the tube comprised between the 7th lateral hole and the mouth-hole. But the flute does not possess any opening in this place, and the performer is forced to blow with greater force, but less than is necessary for the 2nd partial of the first combination.

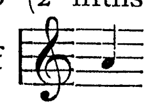
The same observations apply to the production of the sounds , first harmonics of the fundamental tones ; but , 2nd harmonic of , may be produced by opening the hole of , the position of which answers to that of a loop. , 2nd partial of , is obtained by opening the hole of ; the , second harmonic of , is obtained by opening the 10th lateral hole, producing the fundamental ; the , 2nd partial of , is impossible, as there is no orifice, which can be opened in the vicinity of the necessary loop.

There are three modes of fingering for . This note is : 1st partial of the fundamental ; 2nd partial of the fundamental ; and 3rd partial of the fundamental . The 1st fingering employed is seconded by a simple augmentation in the air-pressure; the 2nd is obtained by opening the 12th hole, which gives the fundamental , this opening corresponding to the 3rd part of the length of the tube employed; the 3rd fingering is obtained by the opening of the 5th lateral hole, which gives the fundamental , and corresponds to a quarter of the length of this new column of air.

There are, also, 3 fingerings for ; the 1st, that of the 1st harmonic of the fundamental , by an augmentation in the air-pressure; the 2nd, that of the 2nd partial of , by opening , the position of which allows the formation of the necessary loop (about a 3rd of the total length of the vibratory column of air). The 3rd fingering is that of the 3rd partial of the fundamental ; to facilitate this harmonic, it is necessary, according to theory, to make an opening at a quarter of the total length employed for the fundamental; the 6th lateral hole, that of , corresponds to this and gives the desired effect.

 has two fingerings : one furnished by the 2nd partial of ; the other, by the 3rd harmonic of the fundamental . The 1st fingering is the one most used; to produce it, all that is necessary is an opening at a third of the length of the tube employed; the 13th lateral hole, , in consequence of its medium position, fulfils this condition. The 2nd fingering is difficult; there is no opening to help the formation of the loop here necessary. It can be obtained only by blowing very strongly.

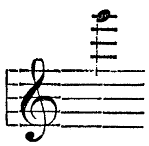
There are two fingerings also, for the : the 1st from the 2nd partial, , obtained by opening the key ; the 2nd, from the 3rd partial of  produced by opening the 8th lateral hole, that of , the position of which corresponds to a quarter of the length of the column of air in vibration.

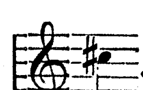
The  can be produced in three different ways : 4th partial of ; 3rd partial of ; and 2nd partial of . The 1st fingering is effected by opening the 4th lateral hole, , the position of which corresponds to a 5th of the entire tube; the supplementary opening of  would make no change in the sound, because this lateral hole corresponds exactly with the place of the 2nd loop (2 fifths of the total length of the tube); the 2nd fingering consists in opening the hole of  equivalent to a quarter of the length of the column of air in vibration (this is the mode of emission usually employed) and the 3rd fingering is produced by opening the key of , an opening which corresponds to a 3rd of the column of air necessary for the fundamental .

 has also 3 fingerings : 4th harmonic of ; 3rd harmonic of ; and 2nd harmonic of . The 1st fingering necessitates opening the hole of ; the 2nd, opening the hole of  (this is the one mostly employed) while the 3rd consists in opening the  hole.

 also, is produced by 3 combinations : 4th partial of  ; 3rd partial of  ; and 2nd partial of . The 1st necessitates opening the  hole ; the 2nd, opening the  hole, the fundamental being taken by the ring-finger of the right hand ; and the 3rd, that of the  hole.

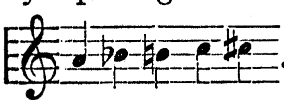
We think it useless to remark each time, that the openings agree with the place of the loop producing the division of the column of air. But we consider it necessary to remind the reader that the openings we mention for the harmonics must be added to the fingering required by the fundamental note whence the harmonics spring. It sometimes happens that exigences of this fingering hinder the opening of the additional hole, necessary for the division of the column of air. This is the case, for instance, with the sound , 2nd harmonic or 2nd partial of the fundamental . To produce this partial, an opening is necessary in the place corresponding to about a 3rd of the total length of the flute, that is to say, the opening of the 7th lateral hole  ; but the mechanism of the flute does not permit the employment of this hole, when the fingering required for the fundamental  is taken.

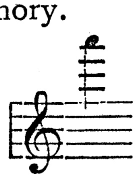
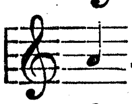
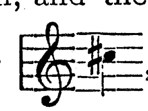
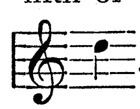
The note  figures in our table under 4 different aspects : as 5th partial of  ; 4th partial of  ; as 3rd partial of  ; and as 2nd partial of . The 1st fingering has for the opening of the 1st loop the  hole ; the 2nd, the  hole, of which the resulting harmonic is too low, because the loop is not at the required place ; the opening of the 7th lateral hole — if it were possible — would correctly produce this harmonic. The 3rd combination has for the loop the  hole, and is the fingering mostly employed ; the 4th combination has no opening suitably placed to aid the division of the column of air into 3 equal parts.

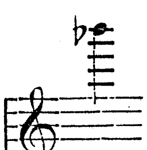
The note  also, has 4 different combinations : 5th partial of  ; 4th partial of  ; 3rd partial of  ; and 2nd partial of .

The 1st fingering consists in opening the  hole; the 2nd, in opening ; in this last case, it is, moreover, indispensably requisite to open the 3rd lateral hole, for, when the latter is closed, the regularity in the shortening of the column of air obtained by the lateral holes is interrupted. The 3rd fingering is generally adopted; it consists in opening the  hole, but, as this is situated a little above the required point, the note is more easily emitted when the  hole is opened at the same time.

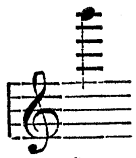
The 4th fingering is hardly possible, because there is no opening which corresponds to a 3rd of the column of air used when the fundamental  is given.

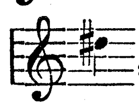
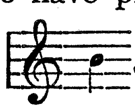
It should be noticed that the usual fingering of the notes  is that which consists in taking the fingering of the fundamentals , by opening at the same time the hole corresponding to their respective higher fourth, . This observation will greatly assist the student by materially diminishing the difficulty generally experienced in impressing these fingerings on his memory.

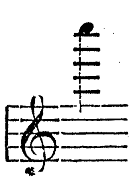
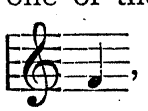
 has 3 combinations: 5th partial of ; 4th of  and 3rd of . The 1st fingering consists in opening the  hole; the 2nd, in opening the  and  holes, this being the fingering mostly employed;  is often added, because  is not quite near enough the place necessary for establishing the loop. To assist, then, the division of the column of air, we open 2 holes, forming 2 loops: the 1st at the 1st fifth, and the 2nd, at the 2nd fifth of the column of air. The 3rd fingering consists in opening , and likewise .

 occupies 4 different positions: it is the 6th partial of ; 5th of ; 4th of ; and 3rd of . The 1st fingering has no opening which

corresponds to the position of the 1st part of the tube, the place of the 1st loop, and is never used; the 2nd fingering, also, has no hole facilitating the formation of the loop necessary for the division of the column of air into 6 equal parts; the 3rd fingering consists in opening the  and  holes, thus establishing 2 loops at the first two fifths of the length of the tube; as to the 4th fingering, which is generally employed, it consists in opening the  hole in addition to the fingering of the fundamental , to form the loop at a 4th of the column of air employed.

The note  is represented in the table by 4 combinations : 6th partial of ; 5th of ; 4th of ; and 3rd of .

For the 1st fingering the  hole may be opened, but we know that the 6th harmonic is naturally too low; the 2nd fingering has no opening to facilitate the formation of a loop; the 3rd fingering is the one employed; it consists in opening the  hole and adding as an opening of a 2nd loop, that of . The 4th combination is not practicable; it would necessitate a 1st loop at , near the 1st quarter of the length of the column of air, and, as this becomes very short, it would be requisite to have a corresponding opening in the 2nd quarter, to ensure the division into 4 parts. This is the more necessary as the  key is not at its right place but in such a way so as to permit, as we have previously remarked, the production of the 2nd partial on the same fundamental .

 would, according to the table, have 5 fingerings : 7th partial of ; 6th of ; 5th of ; 4th of ; and 3rd of . There is only one of these that can be easily produced, namely, the one obtained by the 5th partial of , the division of the tube being effected by the formation of loops at the two first sixths of the length of the tube employed, by the aid of the  and  holes.

We recapitulate the preceding explanations in the following table, which gives : in semi-breves the fundamental tones obtained by the successive opening of the lateral holes; in minims, the series of harmonics depending on these fundamental tones, and in crochets, the lateral holes which must be added to the fingering of the semi-breves or fundamentals, to facilitate the emission of their harmonics.

An examination of this table will show the analogy existing between the laws of the partial vibration of strings, and those of tubes. Violinists know that, to produce on one string the harmonics, 2, 3, 4, 5, etc., they touch the string lightly at a half, a third, a quarter, a fifth, etc., of its length. In shortening a string to ½, a 3rd, a 4th, a 5th, a 6th, a 7th, an 8th, a 9th, of its length, the tone mounts successively an 8th, a 5th, a 4th, a major 3rd, a minor 3rd, another minor 3rd smaller than the preceding; a maxime 2nd, a major 2nd. From these two facts we deduce for all string instruments, the following exceedingly simple theory for the formation of harmonics : to produce any harmonic, we first examine the interval it forms, in the harmonic scale, with the sound which precedes it, and touch the string lightly at the point corresponding to that where it would be necessary to stop the string against the finger board of the instrument to heighten it an interval of the same distance.

Example : The performer wishes to give the harmonic  on the 3rd violin string . This E is the second partial of the harmonic scale of the fundamental A; it makes with the first partial , an interval of a fifth. Touch the string lightly at the point on which you would stop it against the finger-board to give the 5th , and the harmonic  will be the result. If it is desired to produce on the same string the harmonic , it will suffice to touch the string lightly at the point at which you would stop it to produce the 4th , for this harmonic makes with its preceding an interval of a 4th.

This theory of harmonics is the same in every position, for the string, shortened a certain length by the stopping of it by one of the fingers against the finger-board, gives a new fundamental note. But then the production of harmonics is subordinated to the possible extension of the fingers remaining free.

The points where the string is lightly touched are the points of division; the string does not visibly vibrate at these points, which are the nodes. The openings made in the tube to produce the harmonics are the points of the division of the column of air; we have seen that these are called loops. These points of division correspond to the holes of which the sounds make with the fundamental note, intervals equal to those made by the harmonic to be produced with the harmonic preceding it. We find ourselves, then, in the presence of a theory of harmonics absolutely similar to that formulated for string instruments. No exceptions occur save when, as the reader may easily prove for himself,  holes, of which we have noticed the irregular position on the tube, form part of the fingering.

Here we conclude this short treatise. It has given us the opportunity of explaining, completely, and, we believe, for the first time, the system of fingering on the Bœhm flute, a system often considered, especially for the 3rd octave of its compass, as being the result of capricious and inexplicable phenomena; it has also, afforded me the opportunity of formulating a theory, which not only explains the fingerings admitted by practice, but reveals new ones which the performer may turn to account.

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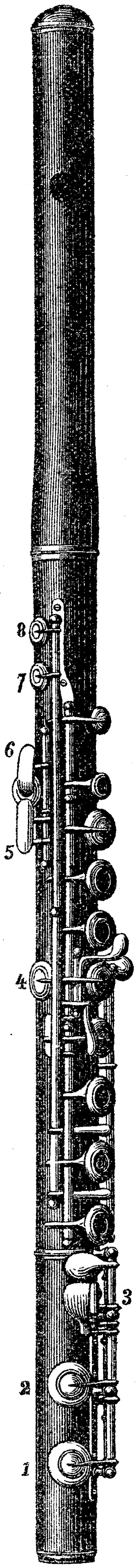

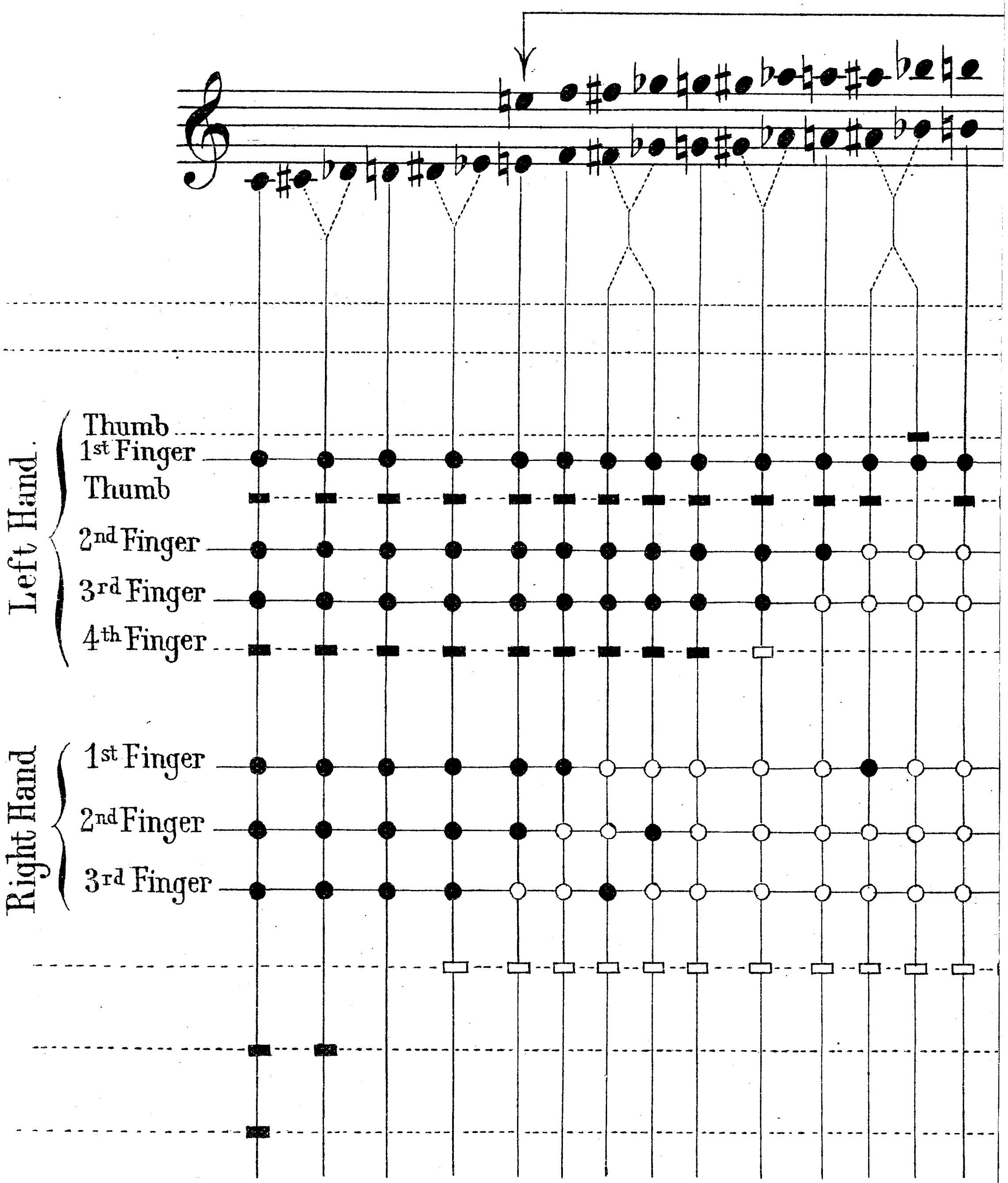

● *indicates the covered finger holes.*

○ *indicates the open finger holes.*

The action of the keys is shewn by a square.

Placed on the lines opposite the keys 1,2,3,4,5,6,7,8 : ▬ , mean

The keys 1,2,3 are worked by the fourth finger of the right h

Key 4, or G# key is closed by the fourth finger of the left

when the use of key 4 is not indicated it may be either ope

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the open or closed G♯ Key.)

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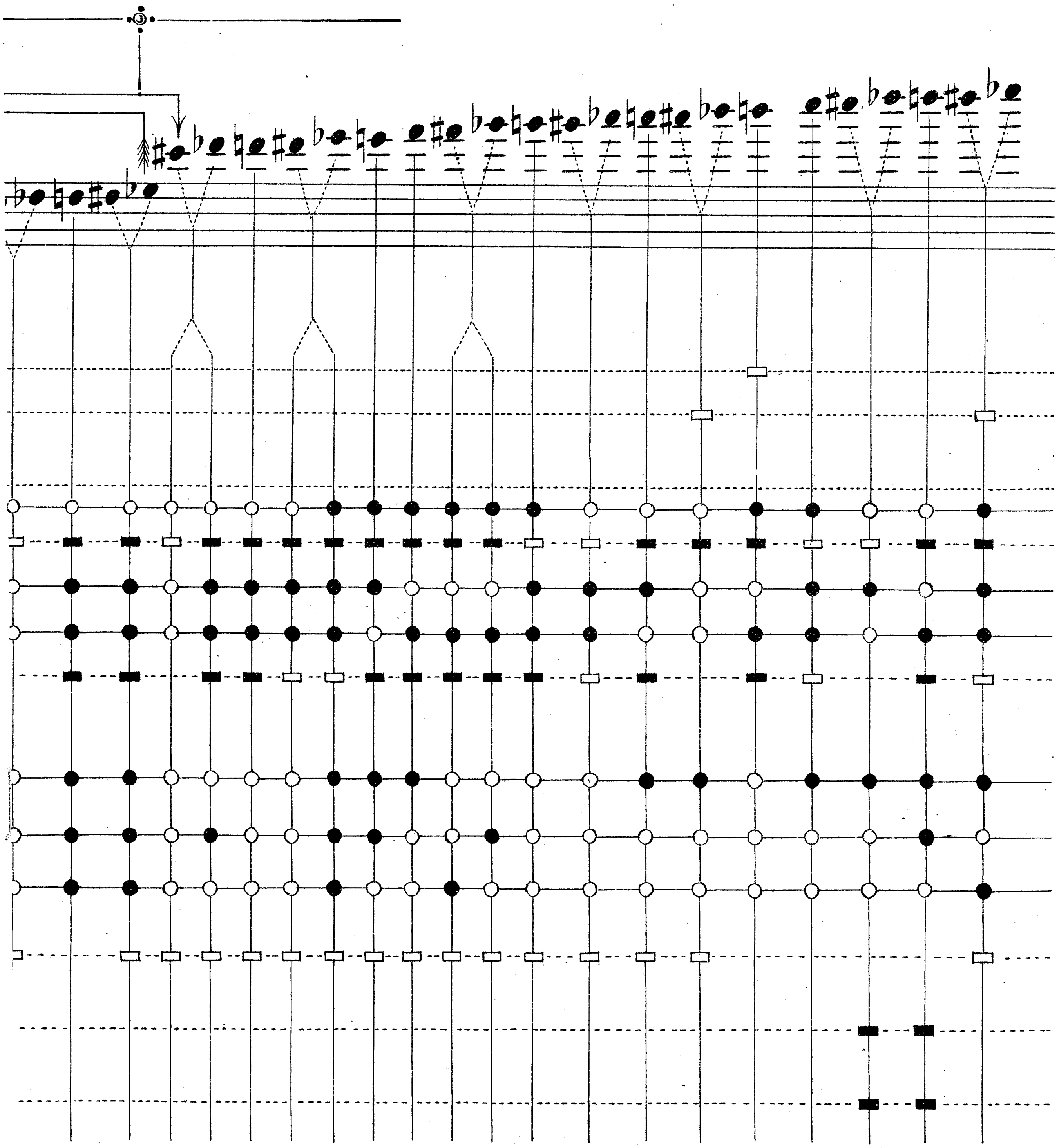

key to be closed; ▭, means the key to be opened.
key 2 may be closed by the fourth finger of the left hand.
in the open G♯ system, and opened by the same finger in the closed G♯ system;
osed. _ Keys 5 and 6 are worked by the thumb of the left hand; key 7 is opened