

derived from this extra hole will be found described in their proper places; for the present it will be sufficient to say that most of the advantages of the "open *d*" are secured without any change in the general fingering being involved.

367. Excepting for the purposes of causing the several octaves to agree with each other in pitch, and making the requisite compensation for the effect of change in the force of the breath, a flute with its tube constructed on the principles advocated above, will require no alteration in the direction of the air-reed, (that is to say, its intonation will be perfectly true, according to the system of equal temperament, unless it be rendered false by unskilful blowing) provided always that opportunities are afforded for reaping the full advantages of the system of construction. These required opportunities form the subject of the next chapter.

CHAPTER XII.

ON THE FINGERING AND THE MACHINERY OF THE FLUTE.

§368. THE FINGERING.—372. DUPLICATE NOTE-HOLES.—373. CROSS-FINGERING.—378. ADVANTAGES OF THE CONSTANT EMPLOYMENT OF ALL THE FINGERS.—379. THE MACHINERY.—380. THE KEYS AND THEIR SUPPORTS.—383. THE FLAPS, LEATHERS, PLUGS, CUPS, PADS AND BEDS OF THE KEYS.—388. THE RISE OF THE KEYS. STOPS.—389. THE SPRINGS.—391. PERFORATIONS IN THE KEYS, ETC.—394. "OPEN" AND "CLOSED" SYSTEMS OF KEYS.—395. LEVERS AND THEIR CONNECTIONS.—396. THE CRUTCH.

368. The Fingering of the Flute. The opening or closing of the finger-holes of any wind-instrument is technically called the *fingering*, and the separate or combined action of the fingers in determining a particular note is called the fingering of that note. It must be obvious that unless a rational system of fingering be adopted, excellence in the material and the construction of the tube can be of no avail. It therefore becomes a paramount necessity that means should be provided for readily opening and closing the finger-holes, either separately or in any desirable combinations.

The historical account of the fingering of the various kinds of flutes will be found in chapters XIII. to XV., we have at present to deal with the principles that should govern the fingering in order that the full advantages of scientific construction may be obtained, neither intonation nor quality of tone being allowed to suffer by the closing of holes that ought to be open, and the consequent improper veiling and flattening of the notes. Compared to these important considerations, facilities

for rapidity of execution, however desirable in themselves, are as nothing.

369. It is not by any means necessary that every finger-hole below that which immediately determines a note should remain open, although Cornelius Ward strongly insisted on the point as an essential condition for perfection. This is a matter that depends much on the size of the holes, but these must be small indeed if the opening of the two holes next in succession below the actual note-hole is not generally sufficient. In the case of holes of .64 inch in diameter, or even three-fourths of that size, the opening of one hole below the true note-hole is all that is generally necessary, and often the opening of the note-hole alone will suffice, but much depends upon the number of the closed holes below the open hole or holes; though when two are open the next two may be closed with less resultant harm than from the closing of a single hole when only one is open above it.

370. A vital point, as regards execution, is the equal distribution of such difficulties as are unavoidable, amongst all the twenty-four major and minor keys. One of the greatest defects in certain systems of fingering consists in their causing some scales and arpeggios to be unnecessarily easy, while they render others unduly difficult and even false. Music in all keys should be playable with equal facility, and all the scales should be uniformly well in tune. Equal familiarity with all the scales is altogether a different matter: this depends chiefly on the industry of the player.

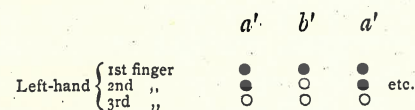
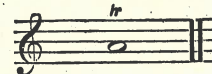
371. Besides fulfilling all the above-mentioned requirements, a really well-ordered system of fingering will possess the advantage of necessitating as few changes as possible in the manner of fingering the notes, particularly in ordinary passages, and when a change is advisable, for the sake of smoothness of execution, it should be such as to cause as little variation as may be in the pitch or the quality of the sound.

372. "Duplicate" Note-holes. For many years flutes were

generally provided with two *fl* holes. The object of the second hole was simply to afford facilities for execution, but this end might have been, and occasionally was, attained by less objectionable means. In the improved flutes, introduced about fifty-seven years since, duplicate holes were entirely discarded, unfortunately they were re-introduced about seventeen years later, and not only in greater number than before, but individually with more mischievous consequences, on account of the greater destruction of the integrity of the bore owing to the increased diameter of the holes. For myself, I have always regarded duplicate note-holes with aversion, and have considered them to be unmitigated and unnecessary evils. Further reasons for this sweeping condemnation will hereafter appear.

373. *Cross-fingering.* This is a term applied to the movement of certain fingers in opposite directions at the same time. That this alternating action of the fingers is not, *per se*, a serious hindrance to rapidity of execution, is clearly proved by myriads of brilliant piano-forte players, but an instrument that demanded no contrary action of the fingers would clearly present greater facilities for perfection of execution than those usually denominated "keyed instruments." We may select a shake as an example.

This shake would be played on the piano by the alternate falling and rising of any two fingers, and therefore there would be two opposite digital motions for every note but the first one. On the flute, the notes of the above shake would be fingered thus:



and there would consequently be but one movement of one finger for each note.

374. The worst kind of cross-fingering on a wind-instrument is that which arises from the alternate opening and closing of two or more adjacent note-holes. The following example is selected from the fingerings of the primitive flutes with six finger-holes only.

1L	●	●	●	●	●	●
2L	●	●	●	●	●	●
3L	●	●	●	●	●	●
1R	●	—	●	●	●	●
2R	●	●	○	●	○	○
3R	○	●	●	○	○	●

It would be found, in practice, almost impossible to uncover the f^\sharp hole and to cover the e' hole at precisely the same instant, consequently an intervening d' or f^\sharp would be almost certain to occur. This will be understood on reference to the crotchets and the fingerings shown beneath them.

375. The fingering of the f^\natural in the example is one of a class known as "fork-fingerings": these are always irredeemably bad, for the reasons above stated, but the fork-fingerings of which this f' is a specimen are especially pernicious on account of the muffled sounds to which they give rise. It will be observed that there is here no note-hole for f^\natural : this note is made by veiling the f^\sharp hole, the sound being thus flattened down to f^\natural at the expense of the quality of the tone. It is impossible to give an adequate description of the hollow dulness of the sounds given by these fork-fingerings. They must be heard to speak for themselves—as well as they can. See §§124, 147, 148, and 347.

376. The least objectionable class of cross-fingerings arises from the alternate use of two holes which have one or more open holes between them. In this case all danger of intervening notes may be avoided, in ascending, by closing the lower of the two holes in question an instant before opening the upper

one; in descending, by closing the upper hole an instant before opening the lower one. The only ill effects resulting from this kind of cross-fingerings are caused when reiterated alternations of notes occur. These remarks will, perhaps, be better understood after the perusal of the explanation of the uses of *keys* for covering the finger-holes.

377. In the two lower octaves of the flute there need be no objectionable cross-fingerings whatever. In the third octave the necessity for opening vent-holes renders the avoidance of cross-fingerings impossible, but these are altogether of a different nature from those of the first and second octaves, and only a moderate amount of skill is required in order to accomplish them so smoothly that their use is free from objection unless the alternate motions of the fingers should have to be repeated, and the same may be said of the change from one of the two lower octaves to the other when the c''^\sharp hole is opened as a vent-hole for d'' or d''^\sharp . In cases of repeated alternations of notes, legitimate use may be made of the opportunities for changes of fingering which are afforded by a well-ordered system.

378. *The Advantages of the constant Employment of all the Fingers.* The attempt, frequently made, to allot more of the general work of fingering to certain fingers which are supposed to be better adapted for the strain than certain other fingers, which, as it appears to be thought, should be left comparatively unemployed, is ill-advised and unphilosophical in the highest degree. The practice of an instrument arranged according to such principles would certainly tend to strengthen those fingers which are naturally stronger and freer in their action than the others, and to weaken and stiffen, by disuse, those which might be made, by constant exercise, almost as strong and quite as flexible as the rest. Not many years ago some opposition was raised to the frequent use of the left hand thumb on the flute. We do not now hear much of this objection to the employment of the most useful of the nine fingers which govern the holes, but there is still rife, in some

quarters, a strong prejudice against the frequent use of the little finger of the same hand, and several more or less cumbrous contrivances, which would appear to have been devised for the purpose of rendering this finger stiff and helpless, by keeping it as far as possible unemployed, are still in vogue. No one has ever objected to the continual use of the right hand little finger, and how there arose a wish to shelve the corresponding finger of the left hand is difficult to understand. Surely it should be the object of every one who aspires to become a flute-player to render himself ambidextrous. Theobald Boehm deserved much credit for his courageous and persistent efforts to bring this finger into activity, by reviving an invention of Tromlitz (1800), in spite of the obstinate resistance of many professors and amateurs whose little fingers had become partly incapacitated by having been habituated to a vicious system.

379. The Machinery of the Flute. As long as performers and their hearers were content with flutes provided with six small finger-holes within easy reach, there was no difficulty in covering these by the unaided fingers, but the size, the number, and the arrangement, of the holes in a modern flute, compel the adoption of mechanism of some kind, not only to supplement the inadequate number of the fingers at our disposal, but also to enable us to close, or even to reach, the holes with any degree of certainty. It may be admitted unreservedly that machinery of any kind on a flute is an unfortunate necessity, but a necessity it is, and the only way to meet it is by adopting a system of mechanism that shall be certain, silent and light in its action; simple in its construction, and reasonably enduring. The task of finding such an arrangement has been no easy one, and the mechanism of the flute has been a *quæstio vexata* for upwards of two centuries. As the requirements of musical art became more exacting, and the consequent necessity arose from time to time for increasing the number of the finger-holes, so the difficulty of providing means to cover these grew in proportion. A flute of our own time is not considered complete

without at least sixteen finger-holes, and we have but nine fingers to spare for the purpose of governing them, the right hand thumb being sufficiently occupied in supporting the lower end of the instrument.

Not the least interesting part of our subject is the history of the various ingenious contrivances that have been invented for supplying the deficiency in the number, the length and the width of human fingers, regarded as aids to flute-playing. This history has its place in chapters XIV. and XV.: we have here chiefly to consider principles and their application.

380. The Keys and their Supports. The pegs and rings described by Bartholinus and others (see §305), which were used for the purpose of covering finger-holes too large, too numerous, or too remotely situated, to be closed by the unassisted fingers, have long been superseded by more convenient mechanical appliances which have been generally called *keys* in England, *clés*, or *clefs*, in France, and *Klappen* in Germany.

The principal thing to be desired in the action of a key is that it shall close, or *stop*, perfectly. A key that stops imperfectly simply reduces the size of the hole intended to be covered, while, according to the position of the hole and to the degree of imperfection in the stopping, the desired note fails altogether, only a wind-rush being audible, or a higher sound is given than the one intended. See §§ 143 to 153, and 161 to 164. No keys can stop small holes with the same certainty, silence, lightness and celerity as the well trained finger-tips, but successive improvements have effected such marvels in the precision of the action of the keys of flutes, that these are now regarded by many players rather as blessings than as the indispensable encumbrances that I consider them to be.

381. From its earliest introduction, the key of a wind-instrument has been made on the same general principle, that is, it has consisted of an appliance of metal, or other hard material, working on a metal pin, or axle, and forming a lever of one of the three orders. Rude contrivances of metal, fixed to the instrument, were at first used to support the axle, and for some

unexplained reason, perhaps for the sake of protection, the key was generally enclosed in a perforated box, or "*poche*." Elaborate engravings of some early wind-instrument keys are to be found in Mersenne (1637), but we are not told that these were ever applied to flutes.

FIG. 25. *Facsimile of a Wood-cut from the Work of Viridung (1511).*

We are informed by Quantz that the touch (*a*) of the old key was divided into two wings or "*croches*," in order to render it convenient to both right-handed and left-handed players.

At a later period keys were supported by wooden *knobs* which formed part of the instrument, and which were simply elevations left on the tube when it was turned in the lathe. In the first instance a ring was left round the instrument, but this was generally partly cut away, sufficient only being allowed to remain to hold the pin and to allow of the formation of a groove for the admission of the key. Thus two cheeks were formed, between which the key worked. These, and also the key, were drilled for the reception of the pin which formed the axle.

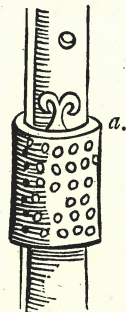
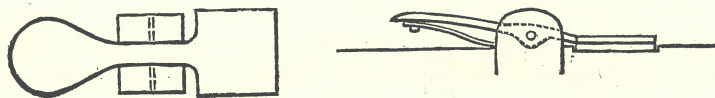


FIG. 26.

Flute-key working between Knobs.

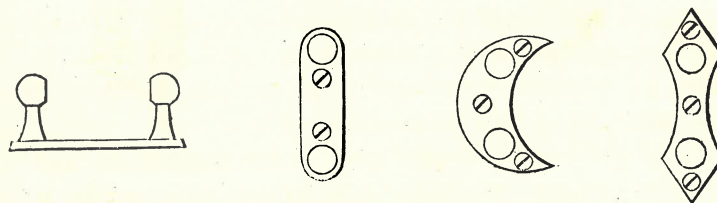


The knobs are unsightly affairs, and the key which they hold soon becomes rickety, but they are still commonly employed on flutes of low price. The metal support has however remained,

in some form or other, in constant use on all kinds of wind-instruments ever since the introduction of keys. The glass flutes of Laurent, mentioned in §319, were first made in 1806. These were furnished with elegant silver pillars similar to those in present use: see figures 27 and 28. The pillars of that time were fastened, in pairs, into metal plates of various forms which were attached to the flute, generally by screws.

FIG. 27.

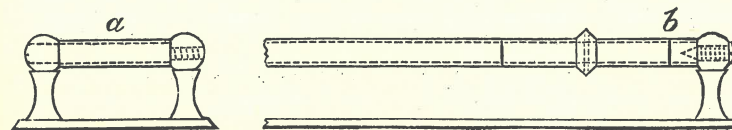
Early Pillars and Plates.



Afterwards it again became the custom to screw the pillars directly into the flute, not always a secure arrangement. Now we have them once more fastened into plates, but the modern plate, or *strap*, as it is termed, extends nearly the whole length of the joint, and one strap supports the pillars for all the machinery of the middle joint, with the exception of those for one key. Another strap supports the pillars for all the keys of the foot-joint. This arrangement affords great security, as well as certainty in the action of the keys.

FIG. 28.

Modern Pillars and Straps.



On flutes with pillars, the keys are often furnished with tubes of various lengths, such as would be called *canons* by watch-makers and *sleeves* by engineers. These tubes partially revolve on steel rods. The rods sometimes pass through one pillar and screw into another, as shown at *a*, *fig. 28*. Sometimes the steel rod requires to be fixed to some other part of the mechanism: in that case the rod works on pointed steel screws, as shown at *b*.

382. The first keys of flutes were of the kind denominated *open*, that is, they were kept open by means of springs until closed by the fingers. These keys were often levers of the second or third order, and they were used, on the larger kinds of flutes, to cover certain holes that the fingers were unable to reach. Sometimes these open keys were jointed levers of the first order.

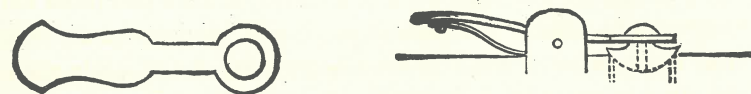
What are termed *closed* keys were subsequently used, and these were kept closed by their springs unless opened by the fingers. Closed keys are always levers of the first order. See *fig. 26*.

383. *The Flaps, Leathers, Plugs, Cups, Pads and Beds of the Keys.* The *flap*, or that part of the early key intended to cover the hole, was at first made flat and square. It was furnished with a leather to render its closure air-tight, and a square flat surface, or *bed*, was worked in the wood surrounding the hole: this facilitated the stopping of the leather. The appearance of the key was, at a later period, improved by the flap and the bed being made circular. The stopping was rendered more certain by lining the hole with a metal tube which projected slightly above it, and which made a permanent impression on the leather.

384. In 1785 Richard Potter of London patented an adaptation of conical soft metal valves, instead of leathers, to the keys. The holes were lined with silver tubes, on the counter-sunk outer ends of which, the valves closed.

FIG. 29.

Key with metal Valve.



The inventor of this contrivance was J. F. Boie, or Boye, a celebrated flute-maker of Göttingen. The valves of Boie's keys were of pewter, and the holes on which they acted were lined with silver. The stopping of these valves, (or *plugs*, as they are now generally termed) was excellent, but their action was extremely noisy, and it was necessary to apply oil to them. They never were very popular, except for the keys of the *c*[#] and *d'* holes, usually named the *c*[#] and *c*[#] keys. Plates were afterwards employed for these two holes, instead of tubes. William Henry, the son of Richard Potter, occasionally discarded the tubes, allowing the plugs to close immediately on the wood.

385. Early in the present century the flaps of the keys were replaced by *cups*, and the flat leathers by *pads*, or cushions, of spheroidal form. These pads, which are still in common use, are made of kid-leather and are stuffed with fine wool.

FIG. 30.

Cupped Key and Pad.



a, Touch. *b*, Shank, or Stem. *c*, Cup.

Plugs and plates are still used for the "*c*" and *c*[#] keys" on certain inferior kinds of flutes, and there is some justification for their continued employment, as the leather-covered pads

are uncertain in their stopping, unless they are compelled to retain the impression of the edge of the hole by remaining generally closed, and the keys in question must of necessity be open when not in use.

The pads under discussion have several defects, and they are ill-adapted for any but very small holes, as they are liable to *bag*, and thus partly to close up the holes when the keys are opened. A stitch of thread passed through the centre of the pad is only a partial remedy for this fault. Moreover, the kid-leather, after having been made wet, an accident to which the keys of all wind-instruments are liable, becomes hard and no longer stops properly, it is, besides, likely to stick to the bed, and not unfrequently the pad leaves the cup of the key and remains fixed to the bed, its only fastening to the cup being shell-lac or sealing-wax.

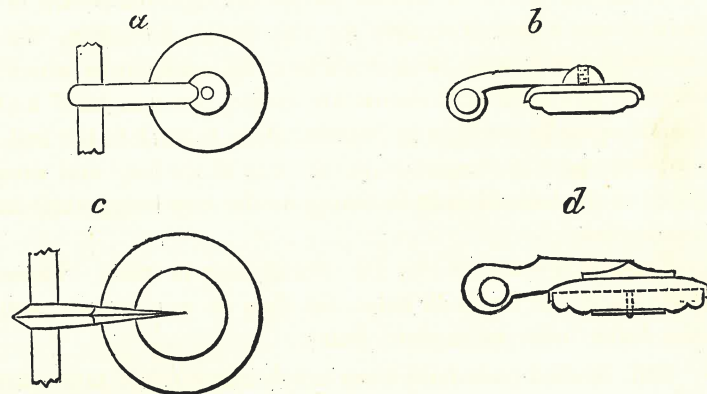
Cork pads were used by Dr. Pottgiesser in 1824. These are not ill-adapted for small holes, but they do not answer well for the large holes of modern flutes.

386. Stuffed pads have been much improved of late years by being made flat, the bases of the cups being also flat. Various materials have been used for the stuffing of flat pads, such as woollen cloth, flannel and felt: the last is to be preferred, and is generally used. Leather is now discarded as a covering for the pads of good flutes, an extremely delicate animal membrane being used in its stead with great advantage both as regards certainty of stopping and endurance. The skin is generally used double. The flat pad has a backing of card-board to keep it in shape, and it is commonly furnished with a circular metal plate, or button, perforated in the centre and fastened down on the face of the pad by means of a small screw-pin fixed to the centre of the base of the cup and passing through a hole in the pad. The button effectually prevents any bulging of the pad. See *fig. 31, d.*

387. The flat cup has been made in a variety of forms. About the year 1831, and for some time afterwards, it was commonly fastened by a screw to the shank of the key, as shown

in *fig. 31, a*, a bad plan, as the cup often turned round on the screw and failed to stop in consequence. This key had, besides, an inelegant appearance. The best and most elegant form of key is shown in *fig. 31, c, d.* The cup of this key is hard-soldered to the shank.

FIG. 31.



a. b. Screw-cup and shank.
c. d. Best form of cup, shank, and pad.

The part of the bed, for this key, which immediately surrounds the hole, is slightly raised, and forms a sharp edge on which the pad closes. By this contrivance perfect stopping is secured with less pressure than would be necessary with any other form of bed.

388. *The "Rise" of the Keys. Stops.* It is necessary that a key should rise to a sufficient height above its bed to permit a free opening of the hole. As a matter of course, the larger the hole the greater is the rise of key required, but in almost all cases the overshadowing of the hole by the key is equivalent to reducing the diameter of the hole; hence this influence always has to be taken into account, and supposing the holes to be of the correct size and properly placed, it is of great importance that all the keys of a flute should have the same rise. For holes

of .64 inch in diameter, the greatest distance of the pad of the key from the edge of the hole, should be .2 inch. A greater rise than this is liable to exercise an adverse influence on the execution of rapid passages, while a rise of less extent is detrimental to the tone. The rise of open keys is regulated by projections, called *stops*, behind the keys. The actual collision of any moving portions of the machinery with each other, or with the tube of the flute, should always be prevented by the interposition of cork, for the sake of silence in the action. The projection which regulates the rise of the key may be conveniently termed a stop, whatever may be its length.

389. The Springs. All keys of wind-instruments must be kept in their normal positions by means of springs, the strength of which should be rigorously adapted to their functions. A common form of the spring of a flute-key is shown in figures 26, 29, and 30.

This spring is generally a strip of steel or brass which works with considerable friction on the wood, or other material, of the flute. Its action is improved by the addition of a counterpart, of a different metal, fixed to the flute by a screw. I believe that these double springs were introduced by the old firm of Rudall and Rose.

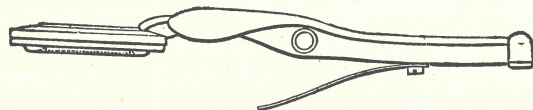
FIG. 32.

Double Spring.

Sometimes, instead of the extra spring, a small plate of steel is let into the flute to lessen the friction, and as long as this is kept lubricated at the place of contact the spring works fairly well. The best kind of flat springs has the point beyond the axle of the key, as shown in *fig. 33*. When this spring is

well made of fine steel its action is perfect, but it is only applicable to certain simple keys.

FIG. 33.

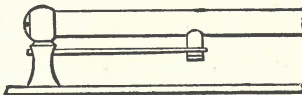
Best form of the Flat Spring.

390. The ordinary spring of steel wire, technically called the *needle-spring*, is generally the best adapted for a flute-key that is mounted on pillars. Of all kinds of springs, this is the most simple in its action, and causes the least amount of friction; it is therefore the least liable to get out of order. It should be made of the finest steel and carefully tempered to a blue colour, unless intended for use in a moist climate, in which case gold is to be preferred.

Needle-springs were first applied to flute-keys by "M. Buffet jeune" of Paris, about the year 1837. Buffet was at that time working under the direction of the able and ingenious Victor Còche, to whom allusion has already been made and of whom much remains to be said, so that it is difficult to decide which of the two was the author of the improvement. Cornelius Ward was the first, in this country, to make flutes with needle-springs. This was not until the year 1842. Their use is now general, though, for some inscrutable reason, it was long in becoming so. Most of the flute-makers, including Boehm, continued to use the old flat springs of brass until the year 1847.

FIG. 34.
Best form of the Needle-spring.

It would have been almost impossible for the flat springs to have been adapted to the complicated machinery of the flute in the later phases of its development. From about the year 1847 all the best manufacturers adopted some form of the needle-spring, but Boehm used an ill-contrived and un-



mechanical modification of it, made of yellow metal. He did not make needle-springs of the best kind until they had been in general use for many years.

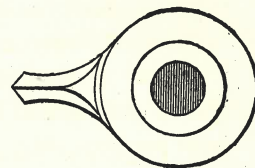
391. *Perforations in the Keys, etc.* From the earliest days of the existence of the flute, down to the present time, it has occasionally been found desirable to cover only a portion of a finger-hole. In the case of the primitive flutes, partial covering of the holes was more necessary than at present, but, even in the highest class of modern flutes, great advantages in the matter of delicacy of intonation are obtained by leaving open a part of a finger-hole. On the flutes with all their finger-holes covered by keys, introduced by Boehm in 1847, this convenience was lost for a time, but M. Godfroy of Paris, at the suggestion of some French professors, contrived perforations in the centres of those keys on which the fingers acted immediately, so that a key could be pressed down on its bed, while its perforation remained open. This idea, though not original, was none the less valuable. To the objections that have been raised against these perforations I have replied (1884, p. 9) in these terms: "Some amateurs [and I might have added, some professors also,] have a strong objection to the perforations in the keys, thinking that there is a difficulty in covering them, and not being aware of the advantages obtained by closing the ring of the key while leaving open the small hole in the middle of it. To such it should be explained that there is no difficulty in stopping these small holes, unless the fingers be absolutely deformed, but that if the feeling against them should be too strong to be altogether overcome, it is indispensable that the key for the first finger of the right hand be perforated, otherwise one of the most useful of the extra fingerings will be lost." The above allusion to the first finger of the right hand applies, of course, only to certain kinds of flutes.

There is one other class of cases, besides those of deformed fingers, which precludes the possibility of using perforated keys, and this truth was recently brought home to me in the person of a little lady pupil, whose fingers, though perfectly well-formed, are at present too small to cover the holes with certainty. The

plan that has been adopted in this instance is simple: we have had the perforations temporarily stopped with cork, and we shall wait patiently until the fingers grow bigger.

392. In a key intended to cover a hole of .64 inch in diameter, the perforation should measure .3 inch. If the rise of the key be .2 inch or thereabouts, the finger-hole will require to be reduced by about .02 inch, as a compensation for the sharpening effect of the perforation. A perforated key is furnished with a metal tube which forms part of the key, and which passes through the pad. On the outside of the tube, but within the cup of the key, is fitted another, moveable, tube with a small flange which, projecting over the pad, answers the purpose of a button.

FIG. 35.

Perforated Key.

If the advantages of these perforated keys were more widely known, and if all flutes were furnished with them, a much needed increase of refinement in the performance of English flutists would be the probable result.

393. Another, and extremely useful, method of partially closing a finger-hole was applied by myself, in 1877, to the key of the c'' hole, partly for the purpose mentioned in §364, and partly for the formation of a certain f''' taken in connection with e''' , as for instance, in a shake. The object is effected in a simple manner by means of a small projection at the back of the key of the b' hole. The projection acts on the stop of the key of the c'' hole, reducing the rise of that key; thus the g''' and the c''' are rendered in tune, notwithstanding the pressure of lip necessary for their production, moreover, the restricted opening of the c'' hole converts the e''' into f''' with manifest advantage as regards facility of execution.

394. "Open" and "Closed" Systems of Keys. Much has been said and written concerning the respective advantages of keys remaining open or closed when free from the pressure of the fingers. No complete system of closed keys has ever been

devised, and it is more than doubtful whether such a system could be efficiently carried out. If it could be, it would, at any rate, be open to two objections: the springs would require to be at least four times as strong as for open keys, and the employment of perforations in the keys would be impracticable. As the open-keyed system, or rather an exceedingly close approximation to it, appears to be the only one capable of consistent application, we must perforce accept it, unless we are content to adopt that most unphilosophical mixture of the two systems which is popularly called the "closed" system, and which is generally represented by eight open and six closed holes: see *fig. 51*, §555. As this heterogeneous assemblage always gives rise to cross-fingerings and veiled notes it is altogether inherently pernicious, but the slight unavoidable deviation from consistency, in the so-called open system, is of no practical importance whatever.

The further consideration of these questions may be conveniently postponed.

395. *Levers and Connections of Keys.* The levers employed for acting singly on remote keys are of the simplest kind, but the closing of two or more holes perfectly, simultaneously, easily and noiselessly, is a matter which requires mechanism of considerable delicacy and precision. Descriptions and figures of the numerous more or less defective methods employed for this purpose, and the steps by which the present near approach to perfection has been attained, in this particular as well as in others, will be found under their respective dates and headings in chapters XIV and XV.

396. *The "Crutch"* is a contrivance that was used by Boehm, and some few others, for holding the flute. Its invention is claimed by Boehm (1847). The stem of the crutch fits into a small metal tube that is fixed to the flute near the *c*" hole: the cross-piece falls into that part of the left hand which lies between the first finger and the thumb. 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, and I have not of late years seen one in actual use.

FIG. 36.

Boehm's "Crutch."