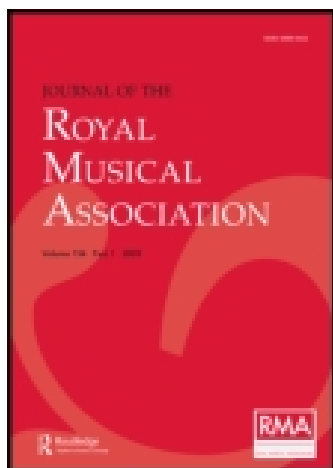


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JUNE 3, 1889.

CHARLES E. STEPHENS, Esq.,

IN THE CHAIR.

NOTES ON THE ACTION OF MUSICAL REEDS.

BY D. J. BLAIKLEY.

THE members of this Association, since its foundation, have been again and again both delighted and instructed by discourses on subjects connected with the art and the history of music. Those of us who have ventured to speak on any scientific point have doubtless considered that as the Association was formed for the investigation and discussion of subjects connected not only with the art and history, but also with the science of music, the framers of its constitution had in view a certain object in admitting science. This object I take to be the wholesomeness and desirability of an occasional descent from the realms of art and imagination, and even of a turning aside now and again from the more human and sympathetic interest called up by the study of the history of musicians and their works. I am encouraged to think that this province, the science of music, may be taken to include not only the study of the laws of the art as deduced from our mental perceptions, but also the examination of all those mechanical actions by which music, the conception and thought of one man, becomes a reality to listening thousands.

The particular branch of musical mechanics which I now

put forward for your consideration is "the Action of Musical Reeds." Reeds form, as a class, a source of sound which is exceedingly widespread both historically and geographically. It would be vain to attempt to fix the time when they came into use; indeed, a moment's examination of certain patterns in use to this day will convince us that the savage need hardly have waited even for the split flint; good sound teeth and a thumb-nail of, perhaps, pre-historic strength, would probably suffice for their manufacture.

Examples.—The "drone" reed of the Highland bag-pipe was shown in contrast with the delicately finished reed of the oboe.

Reeds, mechanically considered, must be regarded as the most important sub-division of the general class of vibrating bars used for music. This class comprehends struck bars, either with resonators, as tuning-forks on their boxes, or without, as the bars of the harmonica and the glockenspiel; and also the bars, plates, or laminæ called reeds, which are put into vibration, not by a blow from a hammer, but by means of a current of air. The essential distinction between the reed and other musical bars is not its greater flexibility, but the manner in which its motion is originated and maintained. For instance, the reed of a Dobell's fog-horn is a blade of steel quite as stiff as many tuning-forks, and much stiffer than the bars of a glass harmonica, and yet it is as truly a reed in its action as the most delicate reed of the clarinet.

Although the manner of reed action has been the subject of much mathematical investigation and demonstration, yet the references to it in books intended for general readers are, to my thinking, for the most part somewhat vague and unsatisfactory. A very slight examination soon convinces us that such a phrase as "vibration caused by the pressure of the air" does not convey much information; the question presented for solution is, "How does the pressure of the air cause continuous vibration?"

A few years ago this question was discussed by Mr. Hermann Smith in a series of articles called "In the Organ and the Orchestra." Although I cannot accept all his conclusions, and believe some of them to be at variance both with theory and experiment, yet in many points I am not merely in agreement with him, but must acknowledge my indebtedness to his treatment of the subject.

Perhaps the most convenient way to illustrate reed action is to take a thin lath or strip of wood supported at one end, and subject it to pressure in various ways. Suppose we apply a weight gradually and without jerk; we find that the position of equilibrium is changed, but there is no other result. Again, let us place the weight on the lath and

remove the hands suddenly; this corresponds to a sudden pressure of wind brought to bear upon a reed. The lath under this influence is carried beyond the position of equilibrium, recovers itself by virtue of its elasticity, and vibrates for a short time; but the force applied is soon dissipated in internal molecular friction, &c., and the position ultimately taken up is the same as in the first case. In this position of rest, there is on the one side the greater static weight or air pressure, and on the other the lesser weight or air pressure plus the elasticity of the reed; these forces balance, and vibration is at an end. Hence we arrive at the following deductions—

(1.) A static pressure produces deflection only.

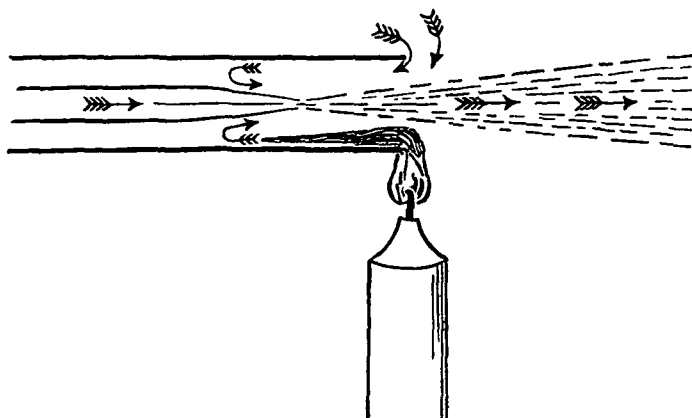
(2.) A sudden impulse or dynamic pressure can originate vibration, but cannot maintain it.

As examples of such suddenly applied impulses, we may note the plucking or striking of a string or a tuning-fork, in which cases we get vibrations which are evanescent in character, and not, strictly speaking, continuous. In order that vibration may be continuous there must be something more than a mere difference of pressure on the two sides of the reed, whether that difference is applied gradually or suddenly; there must be an application of force of the character of a series of pushes or pulls upon the reed so timed with respect to its oscillations as to replace the energy dissipated by its own friction, &c.

A recurring increase or decrease of pressure upon the reed at a certain part of its course provides that which is requisite, and to understand the nature of that variation we must bear in mind the power possessed by a jet, sheet, or column of air in motion, to induce currents in the air contiguous to itself.

As an illustration of such action I have sketched on the black-board a common gas-forge or blow-pipe such as is used by metal-workers of various kinds. When this apparatus is in ordinary use coal gas is supplied through the outer tube, and this is intimately mixed with air forced through the inner tube, which terminates in a small orifice. We may disregard the gas altogether and examine the action of the air-jet, when no gas is turned on. On first consideration, it might be supposed that the jet of air would pass through the surrounding air either without exercising much influence upon it, or that the influence, if any, would be a compression of the air in the neighbourhood of the compressed jet. You will notice, however, that when a lighted candle is held near such a jet, the flame is sucked into the outer tube, showing that the air issuing from the small nozzle carries with it some of the air immediately around it, and thereby causes a rarefaction of the air in the large tube. The outer air rushes in in a direc-

tion contrary to the issuing jet to restore the balance, and carries the flame of the candle with it.



This action of air as applied to reeds appears to be somewhat as follows:—In whatever way the motion of a reed is started, say, as by blowing through a harmonium reed, directly air passes through, it carries with it some of the air on the inner side of the reed, thereby causing a partial vacuum or diminished pressure, and producing the required pull upon the reed; the partial closing of the reed gives the opportunity for the air to recover its normal condition, or at least to approximate towards it, and thus a force of intermittent action is set up sufficient to compensate for the loss of energy otherwise taking place.

This action may vary between a gentle undulation and a discontinuity so great as to give a succession of shocks, and consequently a very complicated wave form, or, in other words, very strong partials, although the motion of the reed itself may be simple harmonic. It is not peculiar to reeds, but it is to be observed when any solid body passes rapidly through the air, or when air passes rapidly by any solid body. The crack of a whip, the whiz of a rifle bullet, and many such noises are due to discontinuous induced currents, causing pulsating or vibratory action, and hence sound. The vibration manifestly does not originate in the bullet, but in the air surrounding it. The office of reeds is to aid, modify, and strengthen this effect; to bring this action, in short, under complete control, so that it may be applied to artistic purposes. In some cases it is possible that reeds act rather by regulating the size of orifice through which an air-jet passes than by any vibrating action of their own.

If we leave out of consideration the natural reeds, the

vocal chords of the larynx, and the lips as used with brass instruments, we find that metal and elastic cane are the two materials altogether, or chiefly used for reeds—metal for those instruments in which one note only is required from each reed, and cane for those instruments in which the reed has to serve for a wide range of notes.

CLASSIFICATION OF REEDS.

METAL	{	STRIKING (limited range of vibration).	{	Old Regal Organ (usually)
		FREE (unlimited range of vibration).		Harmonium—Concertina Organ (rarely)
			ENCLOSED.	OPEN TO THE LIPS.
CANE	{	Single (striking)	{ Bag-pipe drone	Clarinet Saxophone
		Double ...	{ Bag-pipe chanter Cromorne ...	Oboe Bassoon

In making use of the customary distinction between striking and free reeds, I do so without joining in the opinion which some hold that there is any essential difference between them in their action. I believe the difference to be rather one of degree, for it is not necessary for speech that the so-called "striking" reed should really strike its case.

In practical music reeds are always associated with resonating cavities or tubes: those in the harmonium and concertina are usually smaller than requisite to give the maximum resonance to the prime tone of the reed, and therefore one or more of the partials coinciding with the proper tones of the cavity are proportionately more strongly reinforced than the prime. It is partly by differences in the reeds themselves and partly by varying the proportions of the resonating cavities that differences of quality are obtained in instruments of the harmonium class.

In reed pipes as used in the organ, the reed and resonating tube speak one note only, whereas in orchestral instruments the reed has to accommodate itself to many different lengths of tube, and in this lies the great distinction between the two classes of reed pipes. Further, in wood-wind instruments, not only the lowest proper tone of each particular length of pipe is used, but the upper proper tones, the octave, twelfth, and double octave.

The two questions which have given rise to most discussion in connection with reed pipes are, I think, the following:—

- (I.) Does the order of the proper tones, or harmonics, depend upon the reed being striking or free, single or double, or upon the form of the tube?
- (II.) Does the pipe control the pitch of the reed, or the reed that of the pipe?

When a tube is blown by a reed, the orifice between the two blades of the reed, or between the reed and the mouth-piece is so small, that as regards resonance the tube behaves as if it were closed at one end: the proper tones of such tubes, cylindrical and conical, are as follows:—

PROPER TONES OF TUBES CLOSED AT ONE END.

Harmonic series	-	-	1	2	3	4	5	6	7, &c.
Cylindrical	-	-	c	—	g'	—	e''	—	b♭''
Conical	-	-	c	c'	g'	c''	e''	g''	b♭''

I now take a cylindrical tube twenty-two inches long, giving as its lowest tone when closed by the lips and blown the note D, corresponding to the low E of the B♭ clarinet; the next possible note is the twelfth from D—viz., violin A; trying the tube in this way, and also with a clarinet mouth-piece and a bassoon reed, we find that the notes obtainable are the same in every case. We thus find, in the first place, that the pitch agrees with the calculated pitch of a closed pipe of that length, and secondly, that the change of reed, from single (clarinet) to double (bassoon) produces no change of effect. The great difference in length of tube for a given note on the clarinet and on the bassoon is not due to the difference between the reeds, but to the fact that conical tubes are twice the length of stopped cylindrical tubes for any given fundamental note. I have chosen this simple cylindrical tube for the purpose of illustration, but in practice the slight bell of the clarinet gives some small resonance to the upper even partials. When the reed is very strong, we can in some cases throw the air into forced vibrations apparently at variance with the law of resonance above given.

As regards the control over the pitch exerted by the reed upon the pipe, or *vice versa*, in no case is it absolute on one side or the other, but it is mutual, and the extent of it depends chiefly upon the relative mass or strength of the reed and the air-column. A stiff reed has a great power over the pitch of a comparatively light air-column, and can constrain it to its own; on the other hand, a comparatively large mass of air has great power in controlling the pitch of a light reed. When the proper tones or natural rates of vibration of the reed and of the air-column are in agree-

ment, the maximum volume of tone is produced; as these diverge, the pitch changes, the loudness decreases, and in some cases silence takes place. The cane reeds of wood instruments are very light; in these instruments the air-column is the chief factor in determining the pitch, but in some degree the vibrating length or weight of reed can be adjusted by the lips to the note required.

The mutual influence between reed and pipe can be well examined by taking a comparatively light metal reed, and associating it with a pipe. I have here a small carefully weighted bellows, and in connection with it two harmonium reeds of about 1,024 vibrations. One of these reeds is connected with a very small resonance chamber, and the other is so arranged that tubes of different lengths can be added to it. You will now notice that as the tuning slide of the reed-pipe is extended the pitch becomes slightly flatter only; the pitch of the reed by itself would remain constant, but the pipe has some controlling influence. When the tube is extended to a certain length all sound ceases, and it is natural to suppose that the reed is over-weighted by the air-column, and so can no longer set it in vibration. This, however, is not the case, for if I continue to add to the length of the tube, the reed speaks again. The length now added, reckoned from the middle point in the region of silence, is equal to a quarter wave; there is now the possibility of the formation of a node in the requisite position, and thus speech of the reed is obtained. Instead of a quarter wave, we may add, as I now do, a three-quarter, or a one and a quarter wave length of tube, and the reed still speaks freely. On the other hand, if we add a half, a whole, or a one and a half wave length of tube, silence is maintained; making up the last of these, however, from one and a half to one and three-quarters wave length, we again have the reed sounding clearly. In every instance silence depends not upon the actual weight of the air column, but upon the approximate correspondence in position of the open end of the tube with the position required for the formation of a node in the stationary sound wave.

If, instead of changing the weight of the air column by altering its length, we do so by altering its density, the same effects take place; a rise of temperature, or admission of a lighter gas than air, raises the pitch, or even changes silence into speech; every change of temperature or density therefore influences both the pitch and the fulness of tone of a reed-pipe.

It will be at once seen that the few remarks and the rough experiments I have brought forward touch but the fringe of this interesting subject. It naturally opens out in one direction towards some of the most important considerations

in mechanical science—viz., those connected with the effect of the wind upon engineering constructions; and in the other, to the examination of the most wonderful of all reed instruments—*i.e.*, the human voice. With regard to the first of these, it is well-known to you all that although the pressure of wind, as in pounds per square foot, can be tolerably well measured, its actual effect may be very different from that due to its nominal pressure. A great bridge or tall chimney may behave just as a reed does: given certain conditions, and the sole effect will be a slight bending under the blast; change the conditions slightly, not necessarily by increasing the pressure of the wind, and a violent vibration may be set up, possibly ending in a catastrophe. In our experiments with the reed and resonating tube, the pressure of the wind was the same when the reed was merely deflected without speaking as when it was vibrating powerfully, and consequently speaking loudly.

With regard to the voice, although we require to be very cautious in reasoning from rude mechanical devices to a more complex condition of things, yet I think such experiments are suggestive, and if not strained in their application, distinctly useful. When a reed is of one pitch and its resonator of another, greater effort is requisite to produce a certain effect than when both are in sympathy. This state of things may occur in vocal action; also, the tension of a reed, or of double reeds such as the vocal chords, may remain constant throughout the delivery of a sustained note, and yet the note itself may be gradually flattening through alterations in the cavity of the mouth. Many other points will occur to you; if the few I have touched upon suggest any useful ideas, I hope these will be some compensation to you for the tediousness of listening to the somewhat disconnected notes and experiments now brought forward.

DISCUSSION.

THE CHAIRMAN.—Ladies and gentlemen, our first duty is to pass a vote of thanks to Mr. Blaikley for the great research he has undertaken in order to present these interesting details before us. The subject is one on which I suppose there are not many present who will be able to say much, but still I hope we shall hear some valuable remarks after passing a vote of thanks to Mr. Blaikley. [The vote was passed unanimously.]

Mr. HOPPER.—I did not quite catch why the clarinet gave different harmonics to other instruments.

Mr. SOUTHGATE.—I should like to ask Mr. Blaikley one or two questions. His subject is one which, unless it is studied to some extent, one is hardly able to express an opinion of any value upon, but I think we should all be glad of further information on certain points. I would ask Mr. Blaikley first, whether in his experience there is any difference of tone, timbre, or klang-tint in the sound derived from different reeds; whether the material of the reed, be it steel, brass, or cane, has any influence on the tone itself. I would also ask whether the modification of tone which we get when reeds are inserted in the pipe has anything to do with the material; that is to say, whether the shape of the pipe is the sole cause of the tone being modified, or whether it is in any way attributable to the material of which the tube is made. One more question with regard to the old regal. I think there are only two or three specimens in England, and I have never been fortunate enough to see the inside of one. I have seen several abroad, but not the inside. If I remember rightly, in the Germanic Museum at Nuremberg there are some half-dozen instruments there. I once looked at these with a great deal of interest, because, of course, they are the parents of the harmonium, and were no doubt used largely in old times. I was exceedingly anxious to look into one of these ancient instruments to see the material of which the reed was composed, and also how it was placed, but I was not permitted to do so. The guardian of the room pointed to the very strict regulations that were in force, and although one had only to undo two little hooks, and to raise up the frame, he told me it could not be allowed, and I think referred me to Berlin for permission. However, life was too short to refer to the German capital, where probably a Cabinet Council would have had to be held to determine whether one could see the interior of these instruments, so I remained in my ignorance. I should like to ask, therefore,

what is the material of the reeds in these instruments, and their position; if they are placed in pipes, how it is that from a small length of pipe we get notes of very different pitch? I ask this, because Mr. Blaikley has shown by these experiments that the length of pipe does to a certain extent alter not only the quality of the tone, but the note itself.

Mr. BLAIKLEY.—Perhaps as this subject has been raised I may supplement my paper by a little description in detail of the regal. I was more fortunate than Mr. Southgate; I was in Leipsic ten days ago, and happily I had not to go on to Berlin to get permission to see one. I had the good fortune to see a very fine collection of instruments at Leipsic, collected by Herr Paul de Wit, and among them a regal which he kindly took to pieces for me, or at least took two or three keys and their action-work apart to show me the construction exactly, of which I will make a rough sketch on the board.



RESONANCE CHAMBER OF THE REGAL.
A A A Openings. R Reed. T Reed tube.

The resonance chambers are about the same size as in the harmonium for the same notes; there is no large aperture covered by a pallet, but simply a few small holes about $\frac{1}{16}$ th or $\frac{1}{10}$ th of an inch in diameter; at the other end of the resonance chamber is inserted a small reed tube or shallot, carrying a striking reed, which strikes against the face of the reed tube much in the same way as the clarinet reed against its mouthpiece; I think the reed is of brass. The pitch of the cavity was doubtless higher than the pitch of the reed, and the tone instead of being very harsh was modified by the exit being simply a few small holes instead of a large opening.

Mr. HERMANN SMITH.—As regards the regal, there was an old organ in the Exhibition at South Kensington which had a reed very similar to that. The pipes were open at the top, not closed with the pallet; the wind was admitted at the bottom in the same way as in the organ. I think in all these regals we have a variation between the harmonium and the organ; it is neither the one nor the other; for the harmonium is the more complete development of that particular class of reed which is called the free reed. The character of the reed tone appears to be much the same, and the real modification of the tone comes in all cases from the

tube itself, or, I should say, from the degree of occlusion of the tube. That, in fact, is the main feature of a harmonium, and all instruments of that class—the degree of occlusion, of the orifices of the chambers or the cavities in which the reeds speak. You may cause reeds to speak from all sizes of tubes and cavities so long as you vary the degree of occlusion. The actual length really determines very little. You can always find that particular relation of occlusion which will suit the reed, whether it is large or small; but with the very smallest you cannot unless you go to a greater extreme, that is to say, sometimes the mere one-eighth of an inch thickness of wood beyond the reed will suffice to produce silence, and you may add to that thickness little by little until you come to the point when the reed will speak. So it is in going up to a larger size, you may cause the smallest reed to speak into a very large cavity, because it is not influenced by it in pitch; and with the larger reeds—those which we consider the lower half of the instrument—there really seems to be no limit to the character and shape of the cavity you may use. It all depends on how you modify the approaches and the openings; you may have more than one opening with very great advantage; I have made an instrument which represents the clarinet in tone, and which my friend Mr. Southgate has heard. Every note of that instrument is made with the same size of box, the shape of a quarter of a circle, which was originally a little trinket box of Japanese make, of three and a quarter inches radius, and one and three-quarters in depth, having a little drawer swung on a hinge. I bought a gross of these, and determined to make an instrument of them, and from the lowest note to the highest that same sized box is used. The only difference is in the presentation of the impact plates, as I call them, in the face of the reeds and the openings. In most cases I have two openings, so that in free reeds one has no occasion to count upon length of the tube, because you obtain the necessary relation for due speech simply by the degree of occlusion. You may by presenting a little impact plate $\frac{1}{2}$ nd of an inch nearer or farther cause speech or silence; the least fraction will do it. You obtain in this case a very beautiful tone just as you get out of the region of silence. The quality of tone that can be obtained entirely depends on the question of degree of occlusion. The instrument has $3\frac{1}{2}$ octaves.

Mr. SOUTHGATE.—I am very glad to bear testimony to the success of Mr. Smith's experiment (I think I may call it) with the free reed. He, by means of what he has described as impact plates, modified the quality of the instrument so much that I must say had I been in another room I do not think I should have known it from the true clarinet, it was

so very much like it. In conjunction with Mr. Smith's device, we may remember that Mr. Evans, in his little instrument, the *Orchestra di Camera*, obtained some very successful results with free reeds. The most successful instruments, so far as my memory serves me, were the oboe, bassoon, and clarinet; I thought the others were not so good. The tone of each of those instruments was marvelously like the original, indeed it was very difficult to say they were not the ordinary orchestral instruments. How that was done I am not quite clear, but I do remember this, that he told me the principle was not in the setting of the reed in vibration, but in the shape of the cavity which received the sound after it came to the reed, and then the way in which it was allowed to escape. From the very same reed he got the oboe, clarinet, and bassoon tone, which you know is very different. Of course the oboe and bassoon belong to the same family, but although he used similar reeds the shape of the "pans" differed, and so he got tones marvellously like the respective orchestral instruments. There is, I believe, to an intelligent and persevering experimentalist, a great future for the free reed.

Mr. WESCHE.—With regard to the tone of reeds in the harmonium, it depends, I believe to a great extent, on the thickness, and matters like that. The principle of Mr. Baillie Hamilton's Vocalion is practically an adaptation of the harmonium reed. The theory is that each resonance chamber (which was supposed to represent the resonance chamber of the voice) had the same relation to the note as the cavity of the throat to the note you sing.

Mr. HERMANN SMITH.—It is true that instruments of large design, using free reeds, broad channels and chambers, and actuated by pressure of wind, whatever the mechanical arrangements, are virtually harmoniums, though we do not generally like to acknowledge it. Some fourteen years ago I originally planned the type of such instruments, worked them out in diverse ways, with cups and cavities, and broad reeds of many peculiar devices, striving during many years of experiment to develop the musical capabilities of the free reed. Broadly speaking, such work is simply the carrying out of the system of larger chambers for each note than we give in the harmonium. For instance, there would be perhaps a cavity of nine inches long by three inches broad, whereas, in the harmonium you do not get above three-quarters of an inch by four inches. The whole system depends upon giving a sufficient body of air to afford resonance of tone, and of course the working out of all these things depends upon a certain system. Usually the voicing of the reed is of importance. But in the little instrument I was telling you of I did not voice the reeds at all. I simply made the modifi-

cation from the bare harmonium reed tone, by the relation of the cavity and the partial occlusion. The voicing of the reeds seems entirely to depend upon giving the reed a particular kind of curve or bend in a portion of its length, the effect of which, I take to be, is that the reed is thereby better able to resist its tendency to swerve in that lateral quivering which is prejudicial to the character of tone. You give a bend—a twisted bend—to it (in fact, you cannot get that bend out when you have once given it), and it is that which really stiffens the rectangular reed, which is of an undue length, and prevents its quivering in vibration under the varying stress of the wind. When the wind attacks, it attacks sometimes one side of the reed and sometimes the other, and tends to bend and compress the reed on the side to the right or left; then the reed has to recover itself, and there is a want of smoothness in consequence. The only remedy, instead of relying upon voicing, is to have a broader reed. You may have reeds, three, four, or five inches broad. When you get a broad reed then there is a certainty in the movement which the narrower reeds never have. For instance, in a harmonium when we have a narrow reed there is always an oboe tone; if we want a clarinet or flute tone we choose a broad and short reed. Evidently the characteristic of the tone depends on giving the reed that evenness of motion under the varying stress of the air which you cannot get when you have the reeds long. In fact, as soon as the reed dips below the frame it is, as it were, subject to a twist, according to the way in which the air draws off from it.

MR. BLAICKLEY.—With respect to the question which was asked first by Mr. Hopper, the natural order of succession of the clarinet tones is this—one, three, five, seven, nine, &c., like a stopped pipe exactly. The clarinet, the oboe, and bassoon all give the tones proper to pipes of their respective forms and dimensions. The clarinet gives the tones proper to a closed cylindrical pipe, the oboe and bassoon give the tones proper to a closed conical pipe. The difference lies in the distinction between the cone and cylinder. If you change the reeds, as from single to double, between two instruments, and treat them under similar conditions, you would maintain the characteristic series of harmonics proper to each instrument. That is a point that has been disputed, and a different view was brought forward in a paper read here through Dr. Crow a few years ago, which view I ventured to dispute. I have many times endeavoured to find myself in error on this point then, and have not been able to do so. That is all I can say as to my own experience. As regards the material of reeds, the material has a vast influence, there is no question about that; as to

what sort of tone we should get with a metal clarinet reed I cannot say, the thing is rather difficult to work out. I did once try to make an oboe reed of silver, and succeeded to a certain extent; but it was necessary to get the reed down so thin that it would hardly bear handling, it was so delicate. That the material or quality has an immense effect you may judge by this—that two cane reeds between which, by measurement, sight, or any other such test, you can distinguish no difference whatever, may yet differ very considerably in tone under the operations of a good player. A good player will detect at once by sounding a reed that there is a difference between it and another, and although you cannot detect it by sight or measurement, yet not only the player but the listener will detect it when the reed speaks. As there is this difference between different samples of cane, there is a greater difference without doubt between cane and any other material. As regards the various materials of pipes, I would not like to say that there is absolutely no difference in tone due to material, but practically it is exceedingly slight. I have had some practice in testing and hearing tested clarinets in ebonite, cocus wood, and African black wood, which are the three materials most used, and I cannot find amongst those who can really judge that there is any consensus of opinion. One man may say he prefers that or this, but to find two men give exactly the same opinion I have not been able. I think, therefore, the difference is so slight that it may be neglected. I would just like to correct myself with regard to the regal. I am not sure whether the resonance chamber is closed with a pallet or not; I think not, but that the air was admitted in the way stated by Mr. Smith. The instrument was one of the early part of the seventeenth century. With regard to Mr. Smith's remarks as to occlusion, I distinctly agree with him. The thing is manifested there thoroughly.

Mr. SOUTHGATE.—There, from a different quality, you produce different partial tones.

Mr. BLAICKLEY.—You can modify the resonance, strengthening certain partials, and relatively weakening others by altering the position of the holes in the chamber, or its size and proportions. With regard to the question of the voicing of reeds, I am sorry I cannot give much answer, and I cannot add to Mr. Smith's remarks. With regard to the sensitiveness of a reed to any slight variations in the conditions under which it speaks, I can state with great certainty that a difference between the levels of the two cheeks or sides bounding the aperture of the clarinet mouthpiece that can hardly be detected by measurement, will, by throwing a twist upon the reed in closing, upset the quality. I have only to thank you for the kindness with which you have received my paper and remarks.