CHAPTER VII.

ON THE FUNCTIONS OF THE TUBE OF A WIND-INSTRUMENT.

§241. DIVERSITY OF OPINION ON THIS SUBJECT.—243. GENERAL RESULTS OF PERSONAL EXPERIENCE.—244. INFLUENCE OF THE TUBE ON PITCH.—245. INFLUENCE OF THE CONDUCTIVITY OF THE TUBE ON POWER.—247. INFLUENCE OF THE TUBE ON QUALITY OF TONE.—249. ON PERMANENT CHANGE IN THE TUBE CAUSED BY DIFFERENT METHODS OF PRODUCING SOUND.

241. Diversity of Opinion on this Subject. As is the case with regard to many other acoustical matters, there is still much diversity of opinion regarding the functions performed by the tube of a wind-instrument. Space will not permit the reproduction of the numerous arguments on this question, which is really not a difficult one, but the following very brief epitome of the views of the principal writers who have taken particular interest in it, may be useful.

242. Perrault (1680) considered that the sounds of the flute were due to the vibrations of the air-column alone, but that the sounds of the trumpet were assisted by vibrations of the tube.

Bernoulli (1762) proved the sound-vibrations of wind-instruments to be produced by aerial vibrations, but made no allusion to the influence of the tube.

Lambert (1763) asserted that the tube of a trumpet vibrated sympathetically with the air-column.

Riccati (1767) held that the actual sounds of a wind-instrument were due only to the vibrations of the air within it, but that, nevertheless, the nature and the thickness of the materials used in the construction of such instruments, exercised considerable influence on the gravity and acuteness of their sounds.

Chladni (1809) thought that the differences of quality obtained from wood, metal or glass tubes, might be attributed to the different manner of the friction of the air on their interior surfaces, or to feeble resonance of the tubes themselves.

Biot (1816) maintained that it was easy to prove the air-column to be really the sonorous body, but endorsed Chladni's opinions as to the effect of different materials.

Sir John Herschel (1830) says: "If the *qualities* of the tones produced by different pipes differ, this is to be attributed to the friction of the air within them setting in feeble vibration their own proper materials."

Johannes Mueller (1840) held exactly the same views, and laid particular stress on the assumption that the tube of a wind-instrument cannot act as a sound-board.

Professor Zamminer (1852), who wrote at great length, attached considerable importance to the influence of the material and the thickness of the walls of the tube.

Herr Seebeck (1870) directed his attention especially to the effects of different materials on the velocity of the air in tubes, and proved that the nature of the interior surface of a tube had a marked influence on that velocity.

Professor Helmholtz (1885) observed that wooden pipes gave "a softer, but duller, less penetrating quality of tone than metal ones," but he does not appear to have paid any attention to the question of thickness.

243. General Results of Personal Experience. The opinions at which I have arrived, after considerable study of the subject, are as follows: The air-column is certainly, as Bernoulli proved, the chief resonant body in all wind-instruments. The principal function of the tube is a restraining one, that is, the circumscription of the air-column, and its retention within certain limits. Nevertheless, the alternate condensations and rarefactions of the air within the tube communicate lateral vibrations to the tube itself. It can scarcely be said that there is any tranverse vibration of the air-column in the usual acceptation of the term, inasmuch as the whole column does not move bodily from side to side; such transverse vibration as there may be, can only be vibration of rarefaction and condensation, that is to say, of the same nature as the longitudinal vibration. The tube, taken as a whole, expands and contracts alternately, therefore its walls vibrate transversely in the ordinary sense. These lateral vibrations of the tube, under certain circumstances, contribute to the power, and alter the character of the tone, somewhat after the manner of those of a sound-board, but they are altogether different from those of a string or a rod, as it is impossible to cause the production of a harmonic by any kind of pressure on the tube. There is very tangible proof of the lateral vibrations of the tube of a flute, for they can be felt by the fingers while playing.

244. Influence of the Tube on Pitch. Other things being equal, the height of the pitch of a wind-instrument is, within certain limits, directly proportional to the readiness of vibrational sympathy between the tube and the column of air within it. The density, the elasticity and the thickness of the tube exercise, therefore, considerable influence on the pitch of the instrument. If the tube be of moderate thickness and formed of material of moderate rigidity, the pitch may be flattened to an appreciable extent by outside pressure; even the grasping of such a tube by the hand will cause a sensible difference. An ordinary flute, without any metal lining, may be flattened nearly a third of a semitone by tightly binding about four inches of the head-joint with strong cord. This experiment will fail if the joint be lined with metal.

245. Influence of the Conductivity of the Tube on Power of Tone. The following simple experiment proves the effective vibrating and conducting power of a musical tube. Take a rod of pine, such as that described in §6. Place the small end of the rod in the orifice of the ear. Let an assistant sound a small open wooden organ-pipe, and occasionally apply the side of the pipe to the side of the rod, at the broad end, taking care that the open end of the pipe shall project beyond the end of the rod, so that the aerial vibrations shall not travel

along the rod. At every contact of the rod with the pipe, a distinct augmentation of sound will be heard by the listener at the small end of the rod. This increased power of the sound will obviously be due to the vibrations of the walls of the pipe. The vibrations of the rod will also be sensible to the touch of the fingers. A flute head-joint, lined with metal, produces an almost imperceptible effect on contact with the rod.

246. In order that undue importance may not be attached to the effect of the vibrations of a musical tube, and to prove how small is their power of communicating sound vibrations, compared to that of a column of air, place the ear at a distance of about six inches from the open end of a flute, in a line with the tube, while *c'* is being sounded; then place the ear at the same distance from the middle of the instrument, and the apparent strength of the tone will be found surprisingly less than before.

247. Influence of the Tube on Quality of Tone. As there is so much reciprocity between the vibrations of the column of air and those of the containing tube, it will naturally be supposed that the nature and the substance of the tube exercise some influence on the character of the tone, as well as on its power and pitch. That this is actually the case, there hardly seems room to doubt, and yet many have doubted and continue to doubt, in spite of what appear to me to be evident proofs. It must be admitted that this influence is not as great as might have been expected, nevertheless it is a power, and it is necessary that it should be recognised.

Attempts to argue theoretically on questions of this kind, are almost useless. There can here be no guide so sure as experience, and experience will prove to anyone with a discriminating ear, that tubes of different materials and of different thicknesses give rise to marked differences in pitch, character and power of sound.

248. A tube of great thickness and of rigid and dense material, seems to take all life and brightness from the tone of a flute. Such an instrument is sounded with difficulty; its tone is dull and inflexible; it may be loud, but it cannot be good. Insufficient thickness, rigidity or density has, of course, an opposite effect. The tone of an instrument with any one of these defects cannot be loud, though soft notes may be obtained from it with ease; the partials are so prominent that volume is lost, and though such a flute may be sounded with facility, its tone is too weak to be brilliant, and any attempt to obtain power results in harshness; in short, of the whole twelve chief constituents of quality of tone, enumerated in §229, there is not one on which the tube itself does not exercise some influence, either for good or for ill.

Much remains to be said on this interesting topic, which will be conveniently deferred until we arrive at the discussion of the particular qualities of different materials, in Part II.

249. On Permanent change in the Tube caused by different Methods of producing Sound. No unprejudiced person, who has had much experience, can doubt that the tubes of wind-instruments, of whatever material they may be constructed, become permanently affected by the manner in which their sounds are produced. It is necessary to insist on the acceptance of this well-known and generally acknowledged fact, because it has of late been somewhat energetically disputed.

A flute that falls into the hands of a good player will improve in all desirable qualities, as it becomes seasoned, and as it and its master grow accustomed to each other. The tone will become, within certain limits, that which the player desires; supposing it to have been rough, unmanageable and unequal, it will become smooth, flexible and even; supposing it to have been weak, it will become stronger; if certain notes have been slightly out of tune they will be rectified, or at least improved. On the other hand, a bad player may spoil a good flute, or render a bad one worse than it was at first.

I will give one memorable instance of a good flute having been injured by improper usage. A pupil of mine possessed an excellent flute, by Messrs. Rudall, Rose and Carte, of cocus-

wood, well-tuned and of good tone throughout. The tone improved considerably as the instrument became seasoned, but the g''' rose in pitch until its sharpness was unbearable. Now, it must be explained, in passing, that the pitch of this note depends chiefly on the two note-holes for g and c'' (the latter being the vent-hole for g'''), and it is a noteworthy fact that neither g', g'', c'' nor c''', on the instrument in question, was rendered out of tune, but the g''', having been habitually forced for some years, no one could afterwards produce it correctly without the greatest care.

Strange as it may appear, a flute will become accustomed to certain modes of fingering, and will perhaps give a better note with an improper fingering than with what would have been a better one if the constitution of the instrument had not been impaired. I have seen my excellent friend and master, Mr. Carte, try an old flute, and challenge its possessor as to the fingerings he had been in the habit of using, and I never knew him to be wrong, neither do I remember having failed in the same experiment myself.

The only hypothesis that one can offer, in explanation of these curious but indisputable facts, is that the molecular structure of the tube, or of certain parts of it, becomes changed by the peculiar manner in which the enclosed column of air has been caused to vibrate.