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The Throat and The Voice: Part 2, Chapter 2: Acoustics of Voice

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rupted and free passage of the air (Fig. VI.); and they separate a little more during a deep inspiration, and move slightly towards each other during expiration.

In sounding the voice, however, as above stated, the vocal bands are brought together posteriorly to the middle line, and held there as long as the sound is being made (Fig. V.); separating again when a deep inspiration is to be made (Fig. VI.); the process being repeated as long as vocalization is continued. It is thus that the ordinary expiratory current of breathing is utilized in the normal production of the voice. A vocal sound can be produced by the inspiratory current likewise, if a special effort is made to do so, as sometimes practised by ventriloquists; but the sound is rough, coarse, and disagreeable, and the effort soon becomes tiresome and difficult.

In cases of spasmodic approximation of the vocal bands, as occurs in certain cases of false or spasmodic croup, and in a number of diseases of the upper portion of the air-passage, this unnatural vocal sound is actually produced at every forcible effort of inspiration, and constitutes a special alarming and heart-rending sound which is known as stridor.

CHAPTER II.
ACOUSTICS OF VOICE.

The physical laws in accordance with which voice is produced are just the same as those which control the physical production of all other sounds. If, therefore, the general laws of sound (acoustics) are reviewed, and then the mechanism of those portions of the human organism concerned in the production of vocal sound is studied afterward, considerable insight will be gained as to the nature of the voice.

What is sound? "Something we hear," some bright little reader may mentally reply. And so it is,—something that is heard. And it is only by hearing it, that it can be comprehended. The deaf-mute has no conception of the nature of sounds. If he were standing alone by the Falls of Niagara, there would be no sound, for there would be no organ of hearing to interpret as sound the commotion in the water and in the atmosphere produced by the great cataract.

The sensation of sound is due to a certain motion or tremor produced in the molecules of the extreme
filaments of the nerve of hearing, and vibrating synchronously or in unison with the sonorous body. The motions of the sounding body are transmitted in pulses or waves through the air, or whatever other medium it may be, into our ears, and thence along the nerve of hearing into the brain, by which it is perceived and interpreted, and upon which it makes the special impression which we designate sound. Now, whether this motion is communicated from without, as in the ordinary sounds to which we are daily accustomed, or whether it exists primarily in the filaments of the nerve of hearing, the result, in either case, is sound. A blow upon the side of the head often shakes the auditory filaments and produces sound. A current of electricity passed through the organ of hearing likewise produces sound. There is reason to believe that the singing in the ears occasionally heard by nearly every one, and the noises of wind and water, sometimes of music, and so on, to which certain invalids are subject, are all of them the result of a physical motion or tremor set up in the auditory apparatus.

The peculiar form of motion which gives rise to the sensation of sound is that form known as oscillation or vibration; a motion that repeats itself at regular intervals,—a motion to and fro, up and down, forward and backward,—the motion of a pendulum, of the balance-wheel of a watch, of the strokes of a trip-hammer, of a ball kept tossing in the air, etc. The effect upon the air is to produce alternate condensation and rarefaction in spherical waves or undulations, radiating from the centre of disturbance. When this sort of motion is not excessively rapid, that is to say, when it recurs with less frequency than sixteen repetitions in the second of time, it is too sluggish to rouse the organ of hearing, and produces merely some of the ordinary manifestations of mechanical force, as we see in the industrial arts. But when it is more frequent than sixteen times per second, there is special manifestation of sound, whatever the physical work that may be going on; and the pitch, intonation, or acuteness of the sound rises in direct proportion to the increased frequency of the motion,* until, at the rate of from thirty thousand to forty thousand repetitions per second, the effect becomes so shrill and sharp as gradually to transcend human powers of hearing it; when all sound ceases, and our ears are silent to the increased motion. There is abundant evidence, however, to show that vibrations even still more rapid can be heard by insects and other animals. The physical reason that such rapid vibrations fail to impress the organ of hearing, is probably due to the fact that they are too rapid for the weight or density of the nerve-fibres to respond

* Listen to the musical whiz of a steam-saw when sawing lumber, for example.
I. 1

THE THROAT AND THE VOICE.

ACOUSTICS OF VOICE.

92

93

to, and that before these fibres have time to recover, as it were, from the forward motion of one oscillation, the others come on behind with such rapidity as to keep the nerve-fibre pressed still, or dampened, as it were, so that it has no opportunity to vibrate, and is consequently silent.

Away beyond the limits of audition, among vibrations the rapidity of which we cannot realize, amounting to tens of millions per second, the special physical manifestation is perceived as electricity; and far beyond the limits of electric excitation, where the motion begins to be executed in hundreds of millions of vibrations per second, the manifestation of the motion is heat; and when the frequency of vibration amounts to several hundreds of millions per second, the manifestation is light; and beyond the limits of light, the motions produce those still occult forces of decomposition and recomposition known as chemical action. Hence, chemical action, light, heat, electricity, sound, and mechanic force are all manifestations of one universal force—motion. As these manifestations are to a certain extent convertible one into another, we are led to the comprehension of a grand fundamental principle of science known as the correlation of forces.

Strike a match,—one of the most wonderful inventions of human ingenuity, by the way,—and you may demonstrate several of these points at one stroke; a trite experiment, it is true, but striking and brilliant, both literally and intellectually. The friction—mechanic force—develops a rapid vibration of the air around the head of the match, producing one kind of sound, while the explosion produces another; heat is communicated to the wood of the body of the match, which becomes warm to the fingers that hold it; light is produced by the explosion and subsequent ignition of the match, and the wood burns; and chemical action results, as evinced by the cloud of phosphoric acid, and the oxidation of the hydro-carbon of the burning wood; while, furthermore, the presence of electricity, always generated in chemical action, might be demonstrated were an electroscope or electrometer in proper connection with the match. Here, then, we have a variety of motions excited, illustrating the entire series of forces.

Rapid vibrations (at a rate exceeding sixteen per second), then, produce a peculiar effect, which excites that special sensation which is termed sound. At this rate of sixteen vibrations per second, the sound is a low rumble, which almost admits of perception of the coalescence of the sixteen vibrations into a deep tone, as in the sound from the longest organ-pipe, exceptionally used in very large organs, which is thirty-two feet in length, and gives the C of 16½ vibrations per second.

The more rapid the vibrations, the higher in pitch
becomes the sound, until a rapidity of motion is acquired which the ear fails any longer to appreciate; this limit varying in individuals according to the sensitiveness of their hearing apparatus. When these vibrations are equal-timed,—isochronous (isos, equal; chronos, time), periodic or rhythmic,—the effect of the sound is pleasant, and termed musical. When they are irregular or unperiodic, the effect upon the ear is unpleasant and disagreeable, analogous to the optical effect from an irregularly flickering flame, and the sounds that result are termed noisy. Music and noise, therefore, are similar in their physical qualities; and they present points of mutual approximation, although their extremes differ greatly.

The limits of noise and of music, respectively, depend solely upon the degree of pleasurable or displeasurable sensation produced upon the hearer, and vary, therefore, in different individuals, according to the delicacy or sensitiveness of their auditory nerves.

Music, the result of rhythmic or equal-timed vibrations, is audible at greater distances than noise, the result of irregular or unequal-timed vibrations. This greater reach of music is intuitively utilized in the street cries* of large cities, in the auctioneer's rattle-

* Such as those of the rag-men, vendors of fish, fruit, hot-corn, etc. Philadelphians will recall the great reach of the peculiar, musical cry of the "hominy man."

like announcement of bids at a public sale, in calling out to persons at a distance, and the like.

Music and noise are convertible, also. Sounds which in themselves are musical, as the successive tones of the gamut rapidly produced from the pianoforte, for example, become discordantly transmuted into noise if struck together simultaneously. When this is done, the rhythmic vibrations of each string conflict in part, and thus excite irregular movements.

On the other hand, again, sounds which are simply noises as long as they remain isolated, such, for example, as sounds produced by striking a piece of wood, or a paving-stone, may be transmuted into music by striking them in series arranged to yield the tones of the gamut, as in the xylophone, or wood piano, the glass harmonicon, and similar instruments. The musical character of the tones evolved by the rammers of the street-pavers when a series of them are engaged in hammering the cobble-stones of our streets, is well known to residents of cities. It is on record that a series of animals have been utilized as musical instruments. Thus, we read that at Brussels, in 1549, during a celebration in honor of a miraculous image of the Virgin, a bear performed upon an organ of cats. This organ was composed of twenty live cats—with cries giving consecutively the tones of the gamut—confined separately in narrow boxes, over which their
tails passed; these appendages being secured to cords which were fastened to the registers of the organ, and corresponding to the keys of the instrument. Each time that the bear struck his paw upon a key, he thereby pulled on the tail of one of the unfortunate prisoners, and thus forced the series to miau through the whole gamut. Conrad van der Rosen, the jester of the Emperor Sigismond, is said to have succeeded in curing his master of a black melancholy, by executing melodies upon an organ of cats, ranged in gamuts, whose tails he pinched in striking the keys. As sententiously observed by Radau, from whose volume on Acoustics the above anecdotes have been taken, "Cats were not happy at this epoch."

 Sounds, vocal and otherwise, differ in three important characteristics—intensity, pitch, and quality. Attention may be called, in addition, to a subdivision of quality, especially as regards the voice,—reach or penetrant power over distances.

Intensity means loudness, and is independent of pitch or quality. Pitch is the degree of acuteness or gravity, the intonation, or the position of the sound in the musical scale, and is independent of intensity or quality. Quality (timbre, tone-character) is that peculiarity by which the sound of any one instrument or one voice is distinguished from other instruments or other voices, and is independent of intensity or pitch.

**Acoustics of Voice.**

**Intensity.**—Intensity is due to the extent of the vibration to and fro, consequently to the size of the sound-waves or undulations, set up in the atmosphere. Now, bodies vibrating in larger excursion to and fro from their point of rest, set larger masses of air in motion than when that excursion is more limited; and the greater the extent to which the disturbance in the air—really a condensation and rarefaction—reaches, the louder the sound. If we pull lightly upon the cord of a piano, it will vibrate but a short distance to and fro, and the sound will be feeble; but if we pull it more forcibly, it will move over a greater space, and the sound will be louder because a greater mass of air is set in motion, and larger waves of sound generated in consequence. The same thing takes place in the human voice. If the vocal cords (as they are unfortunately called, for they are not cords but bands) are only moderately tense, they can move over a larger extent of space than when they are held more tense. Hence the sound is louder, and the sound-waves being larger, they are felt, in certain portions of the scale, as they strike the walls of the windpipe, bronchial tubes, and air-cells of the lungs,—for sound-waves travel spherically in every direction from the point of disturbance—producing that peculiar vibration of the chest-walls which has given rise to the denomination of chest-tones in the lower portion of the vocal register. The intensity
of the voice depends upon the force of impact of the escaping current of air, and upon the elasticity of the vocal bands.

Pitch.—The range of sound of which the human voice is capable — its compass — consists in round numbers of from two and a half to three octaves; less than that in most voices, more in some rare instances; the entire range, taking male and female voices together, being about five octaves. The extreme limits of human voice observed, however, are said to be the F of 43.5 vibrations per second, in the voice of Fisher, to the C of 2100 vibrations in the voice of La Bastardella. Now, for

the production of every note in the register of a voice, there is but a short pipe, the windpipe, the length of which, by the elevation of the larynx as the sounds rise in pitch, can be so slightly varied as to count for little in the mechanism, and a pair of elastic membranous bands (reeds, tongues, vocal cords), each less than an inch long and less than a quarter of an inch broad, and with but one free surface or edge. The modification of pitch is chiefly effected by progressive variations in the tension of the membranous vocal bands, and by slight variations in the shape of the elliptic fissure between them; a number of complex muscular actions being concerned in bringing this about. This is supplemented by variations in the position and shape of the walls of the larynx and windpipe, pharynx and mouth; but to what extent, or in what manner, is as yet undetermined. The force of the current of air will likewise affect the pitch to a certain extent, as in wind instruments generally.

It is known that if a violin string or a drum-head be stretched, so that its tension is increased, the sound it will yield when struck will be higher in the scale the greater the tension; while the pitch falls as the string or membrane is slackened, because its tension is being decreased. So it is with the human voice. When the laryngeal muscles stretch the vocal cords, increasing their tension, the pitch ascends; and when the muscles are relaxed so that the tension is diminished, the pitch falls. It is likewise known that if a string or membrane is slackened too much, it will not vibrate at all, and will yield no sound; and if stretched too much, it will be ruptured and become incapable of sound until readjusted or repaired. Mere stretching of the vocal bands, being practicable only within moderate limits, will only increase the pitch to a certain extent; and for the further extension of the register, another action of the muscles is requisite, which progressively shortens the free surfaces of the cords.
at the same time that they are rendered tense. If we
examine the strings yielding the higher tones of a
piano, we see that they are shorter and shorter as
these tones rise in the scale; and we know that if the
length of a string on the violin is practically shortened
by placing a finger on it, stopping it, its tone rises in
pitch, and that the shorter the string the acuter is the
sound. Thus it is apparent that the processes in the
human organ, stretching and shortening of the vocal
bands, are the same physically as those employed in
artificial musical instruments for raising the pitch.
The pitch of a sound, as has been said, depends on
the number of vibrations that the generator of the
sound sets up in the air in a given time — the greater
the number of vibrations per second, the higher the
pitch; and it is evident, on a moment's thought, that
the shorter anything is, the more rapidly it can be
moved, and that the tenser it is the more rapidly it
can be moved. The physical laws that preside over
the production of the human voice do not differ in
any particular from the physical laws governing the
production of sound from any other source.

Quality.—It is a point of universal observation
that of several notes of the same pitch and of equal
intensity, one may be distinguished as coming from a
harp, another from a violin, a third from a flute, a
fourth from a human voice, and so on. A musical
ear will distinguish one flute from another, one violin
from another, one voice from another. Nay, more;
it will distinguish the peculiarity of different per-
formers of equal skill upon the same identical instru-
ment, the peculiar ring of the same voice as it is at its
best or otherwise. This difference is quality, or timbre.
It is that characteristic by means of which we distin-
guish the voices of our friends, whom we can thus
recognize in the dark, or under a change of feature,
or of dress after long separation. The physical cause
of quality is difficult of comprehension. It has so
important a bearing upon the cultivation of the voice,
that an attempt must be made to explain it, even in
a little popular volume like this. The quality of a
tone depends, physically, upon the shape or com-
posite conformation of the series of undulatory waves
of sound which collectively produce it. Variation in
the shapes of sound-waves of like pitch and intensity,
or of varying pitch and intensity too, for that matter,
depends upon the fact that all sounds are composite.
Indeed, they are susceptible of being analyzed exper-
imentally into their component factors, by shutting
off the appreciation of portions of the series, on a
principle analogous to that by which a ray of white
light may be decomposed into the prismatic colors
of the spectrum.

In any sound, as that from one note on the piano
or violin, there is a fundamental or ground-tone,
which determines the pitch,— that tone which strikes

9*
our attention prominently. If we listen attentively, however, knowing beforehand what we are to try to detect, we find, commingling with it, other and feeble sounds which are higher in pitch,* and which bear to it certain simple relations of harmony.† Where the harmony of these additional tones—"upper-tones" or "over-tones," as they are termed—is perfect, the effect is very agreeable; and where there is an element of discord, the sound is less pleasant. If we listen to the striking of a bell, such as is used in a town-clock, for example, we shall be able to detect some of these sounds, especially as the ground-tone of the bell is fading.‡ But they exist in all other sounds likewise. They may readily be detected in the graver tones of the piano. It is the relations which these over-tones bear to the fundamental tones, different in different instruments and voices, and dependent in great measure on the shape and character of the instrument and vocal apparatus, which decides the timbre. Each over-tone makes its own impress on the air, as well as the fundamental tone does; and the shape or form of the vibration is made up of the combined effect. Take these over-tones away from the fundamental tone, or conceal them, as can be done by certain experiments, and the fundamental tone of every instrument has exactly the same quality. These over-tones are less prominent in large open organ-pipes than in any other instruments of music; and that is the reason why their sounds are dull and unsatisfactory to the ear.* The organ-builder is aware of the fact that the sounds of large organ-pipes are unsatisfactory, though he may not be aware of the reason; and he has found out empirically—by experimental investigation—that the defect can be remedied by adding a series of pipes of higher pitch, giving the harmonics, as they are termed. And these additional pipes are so arranged that they are all opened simultaneously with the fundamental pipe, so that they all sound together and enrich and reinforce the dull or pitch pipe. This arrangement is called a furniture. In fact, it furnishes the very upper-tones which are deficient in the tone of the large pipe; and when the entire series are sounded together, the combined quality satisfies the ear.

* Some are lower, also, and the two sets produce new combinations of summation-tones and difference-tones; but these are not alluded to in the text, for fear of rendering the elucidation too complex for most of the readers of a scientific primer.

† These comprise the octave above, the 5th of that octave, the second octave, the major 3d of that octave, etc., being due to vibrations of 2, 3, 4, 5, etc., times as many as the fundamental tone.

‡ A globe such as is placed over a gas-jet gives the same results when struck.

* An idea of what is meant can be obtained by blowing over a bottle. The over-tones are weak, and the pitch appears graver than it really is.
Quality or timbre, then, results from the harmonious commixture of a fundamental or ground-tone and its over-tones and their combinations. The delicacy or shade of the clang of the tone varies with the number of these over-tones, their position in the musical scale, and their relative intensity as maintained during the continuance of the tone. The clang is an accord, a sort of orchestral combination in miniature.

The ground-tone of a tuning-fork, as the easiest example to be cited, may be isolated from its over-tones by causing it to vibrate over a rather wide bottle, resonance-tube, or box, the deepest tone of which corresponds in pitch to that of the fork. As the higher tones of the fork differ from the higher tones of the resonance tube, the ground-tone alone becomes intensified, and the over-tones of both are unheard. The mixture of the two ground-tones then results in a simple tone, to all intents and purposes.

With this explanation, it is hoped that the reader can understand that any influence which interferes with the precision with which both vocal bands should be adjusted, in equal strain and tension, will disturb the harmony of the fundamental and upper-tones of either band, or both of them, and thus impair the quality of the voice. This precision of equable adjustment is really greater in a well-trained voice than that acquired in playing upon any artificial instrument of music, and is the main reason of the superiority of execution acquired by a skilled vocalist over that of an instrumental performer. The automatic control of adjustment attained by Madame Mara, whose voice had a compass of three octaves, is said to have been such that she could effect as many as twenty-one hundred changes in pitch, 100 between each two notes of the 21 in her compass. The ordinary capacity of a voice in good culture is stated to be equal to about two hundred and fifty changes, ten or more for each tone of a compass of two octaves, or a little beyond. As each change in the tension of the vocal bands would not vary their length more than the one-fifteen-hundredth part of an inch, we can faintly estimate the extreme delicacy of adjustment of tension of which the muscular apparatus of the vocal organ is susceptible; a delicacy greatly in excess of that acquired in the trained fingers of the most skilled workman. In Madame Mara’s case, the variations of tension between the tones that she could produce would represent a successive lengthening and shortening of the vibrating edges of her vocal bands in successive proportions of one-seventeen-thousandth of an inch,—a marvellous and almost inconceivable delicacy of precision of touch.

The capabilities of well-cultivated phenomenal voices are almost incredible. Thus, among a number of instances alluded to by Mrs. Seiler in her excellent
manual on "The Voice in Singing," it is related of Farinelli, among other things, that "on one occasion he competed with a trumpeter, who accompanied him in an aria. After both had several times dwelt on notes in which each sought to excel the other in power and duration, they prolonged a note with a double trill in thirds, which they continued until both seemed to be exhausted. At last the trumpeter gave up, entirely out of breath; while Farinelli, without taking breath, prolonged the note with renewed volume of sound, trilling, and ending, finally, with the most difficult of roulades."

Reach is the penetrant power of a sound over distance and obstacles, such as other sounds, and is due to the purity of the tone, which, in its turn, is dependent on the accuracy with which it is produced. It is well known that at the great musical Peace Jubilee at Boston, in 1869, the pure tones of the voice of Madame Parepa-Rosa were distinguishable above the accompaniment of a chorus numbering nearly twelve thousand voices, and an orchestra of more than one thousand instruments; and this with audiences estimated at over 40,000 people. A voice, the tones of which are accurately poised, will travel a great distance, independently of its intensity or loudness; and this accounts for the remarkable facility with which some people are heard, even with relatively feeble voices.

The quality of the voice, due, as we have seen (page 104), to the harmonious relation between the fundamental tone of the vocal bands and its upper-tones or harmonics, is largely dependent upon the resonance of the cavities of the throat, mouth and nose, through which the expiratory current of air passes out, and the waves of sound likewise, after the vocal bands have been set into vibration. The vocal bands are the generators of tone; but if the waves set up were not reinforced by the cavities above, the sound would be much like that of the reeds of mechanical toys. This is observed in individuals who have cut their throats in such a manner as to expose the vocal bands to direct inspection. The air, and the sound-waves escaping by the wound in these cases, have not that peculiar resonance imparted to them which they received when they passed through the natural passages; and thus the peculiar or familiar vocal sound is not produced. When the tonsils are enlarged, as in quinsy, for example, this peculiar resonance is impaired, and the voice acquires a characteristic dull and disagreeable timbre or quality, which disappears when the parts resume their normal dimensions. So, too, when the nasal passages are occluded; whether by design, accident, or disease. The influence of loss of teeth on the quality of the voice is well known, and the change is easily apparent when a set of false teeth is removed from the mouth, or used for the first time.
It may be mentioned, here, that the prejudice, existing to a certain extent among vocalists, against removing the exuberant portions of chronically enlarged tonsils, for fear of impairing the voice, is a chimerical one; the fact being the reverse. Clipping off the excess of a permanently elongated uvula, likewise, far from injuring the voice, occasionally improves it, though there is usually no effect noticeable. The irritation excited by leaving it unclipped, on the other hand, may impair the voice considerably.

When the cavity resounds to the fundamental note of the vocal bands, or to one of its higher harmonics or over-tones, the sound is reinforced in a peculiar manner. The interior of the throat, mouth, and nose is to the vocal bands what the case of the violin is to its strings, the sounding-board of the piano to its strings, the body of a reed instrument to the reed, and so on. The sounds of the strings and reeds in unison with the sound yielded by striking the case, sounding-board, or pipe, or in unison with their over-tones, are those most strongly reinforced. So, too, with the voice. The sounds of the vocal bands in accord with the sound proper to the shape of the resonant cavity of mouth and throat at the moment are those which are most reinforced; and as the proper sound of the resonant cavity of the voice varies with its shape, so, for the time being, the sounds vary which it can reinforce at the moment. If a series of fillips are given to the cheek with the finger, while the mouth is opened wider and wider, a different pitch will be given to each sound produced. The trick of imitating the flow of liquid from a bottle in this manner is a familiar instance. The pitch at any given moment of the experiment is the pitch of sound of the vocal bands which will be most reinforced by that position of the mouth. The motions of the mouth, tongue, palate, and throat vary the shape of the cavity, and its capacity of resonance, for different portions of the scale. This fact explains the impossibility of making certain sounds of certain pitch, unless the mouth and its contents are maintained in a suitable position attuned to that pitch.

The influence of the pitch of a sound in exciting a silent instrument attuned to the same pitch is well known to musicians. The response of a glass gas-globe to certain tones of the voice, for example, or the rattling of a pane of glass from a similar cause, must be familiar to all. The waves of sound set up in the first instance are powerful enough to start the vibration of the responding body. The effect is mechanical altogether. It is similar to the effect of rhythmic vibration of a suspended bridge which may accumulate force enough to throw it down. Hence marching in time is prohibited upon suspension bridges. There is an old saying that a bridge of this kind could be destroyed by continuous fiddling on a note of the same pitch.
pitch as that of the bridge, from mere accumu-
lation of force in the sonorous waves. Heavy bells are
started by commencing with gentle impulses in rhyth-
mic accord with the proper oscillation of the bell.
To quote from an excellent novel (Middlemarch,
Chap. XXX.):

"How will you know the pitch of that great bell
Too large for you to stir? Let but a flute
Play 'neath the fine-mixed metal! Listen close
Till the right note flows forth, a silvery rill:
Then shall the huge bell tremble — then the mass
With myriad waves concurrent shall respond
In low, soft unison."

The shape of the resonant apparatus (cavities of the
throat, mouth, and nasal passages), therefore, has
great influence on the quality of the voice. Altera-
tions of configuration by disease impair the voice,
and alterations of shape by design modify it. The
peculiar vowel sounds of spoken language are found
to be due to the shape given to the resonant cavity
in their emission. Thus, with the mouth wide open,
the only sound that can be made by the vocal bands
alone, is the vowel sound \( ah \) (or \( a \), as in father); and
as the mouth is gradually closed up more and more in
front, it becomes possible to make the vowel sounds e
(or \( a \), as in hate), i (or \( e \), as in mete), o, u or oo, and
the compound vowel sounds nearest to each pure
vowel sound respectively. There are also modifica-
tions in the position of the tongue and of the soft
palate which favor the emission of these sounds; but
it is beyond the purpose of this little volume to do
more than call attention to the fact that the difference
between the vowel sounds of a language is chiefly one
of quality or timbre, the vocal bands or factors being
merely the exciters of the sounds. A few experi-
ments before a looking-glass, with the finger in the
mouth, upon the tongue, or against the palate, will
teach any one the positions assumed by the tongue,
palate, and lips in the production of these sounds;
and the change made in the character of the vowel
by altering the shape of the mouth while sustaining
any sound made by the vocal bands, is readily de-
tected. The differences between the vowel sounds
of different languages, or of the same language as
spoken in different localities (dialects), are due to the
difference impressed on the shape of the resonant
cavity, chiefly of the mouth; and the habit of pro-
ducing vowels in a certain manner is so strong that
adults, even with correct ears for musical intonation,
are unable to screw their mouths up, so to speak, in
such a manner as to produce the vowel sounds of a
foreign language accurately; hence, the broken Eng-
lish of foreigners, or the permanence of foreign ac-
cent. Children, on the other hand, whose organs
are flexible, and have not become too much habituated
to the special accents of their mother-tongue, acquire
greater facility in a foreign language, so that, often, very little of their original accent is apparent in speaking the newly-acquired language. The children of foreigners in this country, who habitually speak the language of their parents in their homes, rarely acquire an English accent absolutely free from foreign tinge.

So important is it deemed by some teachers of vocal art, that proper positions of the mouth should be maintained for certain sounds, that they actually make their pupils practise before a mirror until they become expert, or have learned to break themselves of adopting awkward positions of the mouth and its contents, which impair the purity of the tone, or attract attention as contortions or actual deformities.

It is thus evident that the human vocal apparatus—lungs, windpipe, larynx, mouth, throat, and nose—is a musical instrument, capable of rendering shades of expression far more delicate than any that can emanate from a musical instrument "the work of men's hands." It is emphatically a reed instrument, with bellows (lungs), pipe (windpipe), reed-box (larynx), two flexible reeds (vocal bands), and resonance attachment (throat, mouth, nose). These parts are movable upon themselves and their adjacent structures; and are kept moist and flexible by a bland lubricating fluid continuously secreted from the glands of the delicate mucous membrane which covers and protects them.

CHAPTER III.

VARIETIES OF VOICE.

FOUR chief varieties of voice are recognized in vocal music or utterance;—two in the voice of the male, and two in that of the female. These are the bass and tenor, and the contralto and soprano respectively. The peculiarity depends in part upon the natural pitch of the voice, and to a much greater degree upon its timbre or quality. The bass voice descends lower in the scale than the tenor, and its strength and beauty are resident in the graver notes; still, some bass singers can ascend as high as the tenor, though not with equal richness and delicacy, for the peculiar power of the tenor voice resides in the higher notes. In like manner, the contralto, whose superiority is manifested in the lower notes, may ascend as high as the soprano, but without the melody of the soprano, whose forte is in the higher notes. A baritone voice is a tenor voice possessing but a moderate compass in the higher scale, and yet incapable of going very low; and a mezzo-soprano is a soprano voice in the same relative condition.