Sexton (S.) From the Author

THE RELATIONS

OF

THE CONDUCTING MECHANISM OF THE EAR

TO

ABNORMAL HEARING.

BY

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THE RELATIONS OF THE CONDUCTING MECHANISM OF THE EAR TO ABNORMAL HEARING.

BY SAMUEL SEXTON, M. D., NEW YORK.

An attempt to solve some of the remaining mysteries of audition will, it is hoped, be received with patience by otologists, and it may be premised that as physiological researches upon this subject have taken the lead of all others, our views have been, to a great extent, founded upon their theories. Some of the conclusions arrived at by physiologists concerning the functions of the inner ear are truly remarkable when the paucity of facts at their command is considered; and their acceptance by aurists has had, perhaps, too great an influence upon their investigations, inducing them to adapt the teachings of pathology to these plausible theories; and it is to be feared they have been only too willing to refer the unexplained workings of the mechanism of the middle ear to the labyrinthine realms of the inner ear. Fortunately for otology, the physicist has not been able to warp his researches in acoustics to suit any *theory*, however much he may have been diverted from his scientific pursuits in this direction by the doctrines of physiologists. Pathological observations have long seemed to lead to the conclusion that many abnormities, hitherto regarded as lesions of the inner ear, could be explained by recognizable changes in the domain of the middle ear; and, in order to make myself clearly understood on this subject, I shall endeavor to group my remarks under three divisions, namely, Phonation, Conduction, and Perception, although in referring to audition, in general, it will not be easy to so restrict the subject.

Phonation. — Although all sound concerns hearing, the relations of phonation to it are the most intimate.

March 8th 1879

12 West Thirty-fifth St.
New York

John S. Billings M.D.
U. S. A.

Dear Doctor

By to days post I have forwarded to you my article on the relations of the Cond. Opp. to Abnormal hearing. The title not appearing in the Index Medicus. I presume I neglected to forward a copy before.

Yours Sincerely
Samuel Sexton

The vocal chords, which are contained in a cartilaginous apparatus composed of the thyroid and cricoid cartilages and supported by the windpipe, are most favorably situated for imparting their vibrations not only to the air in the throat, mouth, etc., but also to the tissues of the neck which surround them. The position of this musical box upon the windpipe doubtless improves the sonorousness of its vibrations.

The vibrations from the vocal chords reach the ear by two distinct routes: one being to the mouth cavity, and thence through the ambient air to the external meatus; the other route being through the tissues of the neck and head, — muscle, bone, etc., — to the drum, the directness of their course depending upon the conductivity of the various tissues which intervene. The vibrations by the latter route are not heard in the normal condition of the ear, at least not as distinguishable from the former. In some instances the sound waves pass from the mouth to the drum, by aerial conduction through the Eustachian tube, as I have demonstrated by means of the diagnostic tube passing from the patient's ear to mine; this state of things, however, is rare. We have here to do mostly with the sound which reaches the ear through the tissues, and in order to appreciate their importance it is well to consider for a moment their behavior. This is best illustrated by that wonderful invention of Edison's, the talking machine. It is well known that the ability to talk remains to those who have lost what were considered most important portions of the organs used in speech, namely, the tongue, nose, epiglottis, etc.; but the simple nature of the essentials to voice was left to the phonograph for elucidation. It shows that perfectly intelligible voice can be produced without the aid of the mouth, nose, etc.; although they were instrumental in forming the words recorded, the instrument emitted them again without their assistance. By the aid of the phonograph and telephone, Jenken and Ewing have shown that the vowel sounds do not, as Helmholtz thought, depend upon notes of absolutely definite pitch. The pitch of these sounds as spoken by the phonograph varies with the rapidity with which its cylinder

revolves, but *character* is maintained, however rapidly the words may be spoken by the machine.

Observation has shown that the vibrations of the vocal chords reach the ear with the same constancy through the tissues as by the mouth and ambient air. *Persons absolutely deaf to external sounds still hear their own voice.* In order to determine whether the mouth, nose, etc., had any influence in forming the voice heard under these circumstances, I had a suitable trumpet constructed which conveyed my own voice into the mouth of the deaf person. The result was, when I spoke distinctly into the mouth, *noise* was heard plainly, but he could not distinguish one word from another, excepting as to pitch. It is therefore evident that voice can reach the auditory nerve without receiving the aid of the mouth, etc.

The weight of evidence, I believe, is now against the theory that in man the Eustachian tubes are capable of permitting aerial conduction from the mouth to the ear, when in a normal condition. This was the belief of Schelhammer,[1] and J. Muller coincided partially with him.[2] (Cited by Rouis.)

The mouth trumpet, however, when used by me in cases where deafness was very great, conveyed voice to the ear as well, and in some instances better, than the ear trumpet. This may be accounted for by the fact that mouth reception permitted vibrations to reach both ears at the same moment.[3]

CONDUCTION OF SOUND. — Before considering the anomalies of conduction it will be well to take a brief view of some established points in normal conduction. The extreme fineness of the membrana tympani is the first thing to attract attention; it is only 0.1 millimeter in thickness, and is capable of transmitting from 16 to 40,000 vibrations a second to the auditory nerve. This delicate movement of the membrane is equaled by that of the stapes in the oval window, whose excursions in the fainter, but still distinguishable tones,

[1] *De Auditu, Leyde*, 1784.

[2] Loc. cit., t. 11, page 432.

[3] The subject of "Transmission of Vocal Sounds by the Eustachian Tube" is discussed in *Recherches sur la Transmission du Son dans l'Oreille Humaine*, par J. L. Rouis, S. M. P., Médecin Principal d'Armée, etc., Paris, 1877.

are so small as to escape detection with the highest powers of the microscope.[1] (Reimann.) Keeping these facts of audition in view, we may here state that Edward Weber regards the bones of the ear and the petrous portion of the temporal bone as solid, incompressible bodies, and the fluid of the labyrinth as an incompressible fluid; and the bones of the ear must be considered as solid levers which transmit waves of condensation and rarefaction to the fluid of the labyrinth, moving it as a whole.[2]

The description of some of the movements of the conducting mechanism, in Helmholtz's own words, will make the allusions further on more readily understood. Helmholtz says:[3] "The joint between hammer and anvil admits of a slight rotation about an axis drawn transversely through the head of the hammer toward the end of the short process of the anvil; a pair of cogs oppose the rotation of the manubrium inward, *but it can be driven outward without carrying the anvil with it;*"[4] and "with a joint of this nature a *slight displacement*[4] must necessarily take place between the hammer and anvil whenever the end of the handle of the hammer is driven inward." . . . . "By means of an increase of pressure in the cavity of the drum or diminution of pressure in the meatus, the membrana tympani can be perceptibly driven outward without the stirrup incurring the danger of being torn from the fenestra ovalis." The membrana tympani serves as a powerful resistant to the reverse movement of the hammer. As regards the further action of the mechanism, Helmholtz says: "The excursion which the hammer can make without the anvil is nearly nine times as great as that which the two together can accomplish. *This kind of movement is not transmitted to the water of the labyrinth*,[5] excepting of course the slight changes in pressure which the changed tension of the articular ligaments, or the rubbing of the articular surfaces

[1] Helmholtz, translated by Buck and Smith. New York, 1873.
[2] Loc. cit., page 9.
[3] Loc. cit., pages 33, 38, 44, 48.
[4] The italics are the present writer's.
[5] The italics are the present writer's.

of the malleo-incudal joint upon one another, is perhaps capable of producing in the water of the labyrinth when the cogs of the articulation are no longer in contact."

From the above it is seen that in health a very free motion or a separation takes place in the malleo-incudal joint, and when this separation has been further increased by pathological changes, there may occur the symptoms of autophony, tinnitus, etc. The anomalies which induce these changes in the delicate mechanism described are principally as follows: Hyperæmia and inflammation of the drum, and their results, namely: anomalies of tension of the drum membrane; pathological changes of the ossicles and their articulations; pathological changes in the tympanic muscles.[1]

Probably the most frequent change in the membrana tympani is thinning of its layers from the atrophy occasioned by hyperæmia, a condition which is permanent. (Described by Stifler, of Munich.) Stretching is not unusual in this condition.

Temporary alterations of the membrane, as regards thickening and tension, are caused by acute and chronic inflammations, and the presence of fluids in the cavity may further increase the abnormities of tension.

The ossicles and their articulations and the tympanic muscles are more or less affected by the same causes. The transmission of sound is also affected by anomalies of the membrane from thickening, calcification, cicatricial changes, severe concussions, attended with inflammation, hyperæmia, or rupture of the membrana tympani, such as are produced by the hammering of metals, by sounding of steam-whistles, discharge of explosives, artillery, small arms near the ear, and the like, blows upon the ear, violent entrance of foreign bodies wounding the middle ear, impacted collections of cerumen, etc.

It is very difficult to elicit an intelligible account of their symptoms from patients who are the subjects of the abnormities we are about to enumerate as arising from these causes. This is owing to their inability to describe acoustical phe-

[1] For a complete description of the pathological anatomy of the ear, consult Schwartze, translated by J. Orne Green. Boston, 1878.

nomena, of which they usually have but little knowledge. Musically educated persons are greatly confused under these circumstances, as will appear further on.

I have found these symptoms prevailing in a much larger number of patients than was suspected before my attention was specially directed to this subject, and before particular efforts were made to obtain an account of symptoms under such difficulties. Where the symptoms are very marked the patient usually describes them as follows: hearing double; hearing an echo or reverberation in one or both ears, when phonation is performed; hearing own voice as distant, slow, down in a well or pit; hearing own voice as though speaking in an empty vessel; hearing own voice as muffled. Others describe their own voice as "going out of the ear from within;" some describe the sensation as a "feeling of the head being empty." When a person of inferior mind is closely pressed for a description of these anomalies of hearing, he confesses his inability to do the subject justice, and very likely asks if his speech does not explain itself. In fact, most patients have the belief that others hear their voice as they hear it themselves, *i. e.*, abnormally.

Musical people, when affected with autophony, not hearing their own voice naturally, are unable to sing correctly; they fancy that others do not sing in tune. It is difficult to convince them that they can hear musical instruments correctly; but when they give the matter close attention it is found that they can hear external sounds correctly, although in some cases with difficulty, owing to the deafness to all external sounds, from interference. It has been found to be a good plan to request the patient to whistle, which is not an effort of phonation, and can therefore be heard by him externally.

The ignorant and superstitious are sometimes haunted by dreadful imaginings and foreboding of impending evil.

While seeking an explanation of these symptoms my attention was directed, in June, 1874, by a clergyman who was under my care, to the fact *that he could hear his watch tick only when he laid one ear over it.*

This was at the time inexplicable to me, and the only cause

for its occurrence seemed to be some condition of the inner ear which was affected by the position of the patient's head; but many observations failed to throw any light on the subject. In September, 1876, by another case[1] my attention was first directed to the conducting apparatus as the true source of these abnormities.

This patient, while under my treatment for deafness arising from a subacute inflammation of the middle ear, found that *when he immersed his head under water, in diving, his hearing instantly returned*, although he became deaf again shortly afterwards. Subsequent observations have confirmed my suspicions as regards these conditions, and when the anatomy of the conducting mechanism is considered, together with its extreme delicacy, we can readily see that slight pathological changes are capable of producing the symptoms of autophony, tinnitus, etc.

Autophony does not occur, so far as I know, when the membrana tympani is absent; and furthermore, *the existence of a perforation does not prevent its occurrence, provided the ossicles and their attachments are not thereby affected.*

Total deafness to external sounds in both ears prevents, of course, the occurrence of double hearing, as the patient then cannot compare the hearing of his own voice, transmitted from the vocal chords through the tissues, with his voice as received through the external meatus. Patients affected with double hearing speak in their usual tone of voice with great difficulty, since they do not hear it as coming from the outside, and, fancying others cannot hear them correctly, are prone to elevate their voice accordingly.

Double hearing, as will be explained hereafter, is, in a certain number of cases, variable, and the person so affected will change his voice during conversation or reading aloud every time his own hearing is altered. This usually distresses patients very much, and is equally unaccountable to the auditor.

While writing this article I have been visited by a patient

[1] See report of case in *New York Medical Record*, January 13, 1877.

who has the peculiarity of hearing double, "like speaking into an empty vessel," when he is up and about, but the moment he lies down the abnormity disappears; when he rises from any reclining posture the double hearing returns with a snap, owing to the friction of the malleo-incudal joint. In my note-books are the records of several cases, persons long subject to this symptom, where *normal hearing is restored by pulling the auricle in an outward direction. Sometimes the same result is accomplished by swallowing or yawning.*

Hearing the ticking of a watch, and not hearing ordinary conversation (and the contrary), and hearing better or worse in a noise are explainable by the condition of the malleo-incudal joint or membrana tympani, or both. Burnett relates a case where a young lady *heard all sounds normally with the exception of thunder*, the low rumblings of which she could not hear at all.[1] Mr. D. Greenberger, Principal of the Institution for the Improved Instruction of Deaf Mutes, New York, informs me that during the prevalence of a thunder-storm *many of the deaf mutes in the institution cry with the pain produced by the low concussions.*

A patient now under treatment for absolute deafness for the voice, was standing upon the battery when the sunset gun was fired at Fort Hamilton, about one mile distant. The unexpected concussion almost prostrated him, and he did not recover from the actual pain in one of his ears for some hours; the parts in the neighborhood of the ear were tender to the touch for a day or two. A word spoken in a very low tone, or a whisper directly in the concha of this patient, is painful, whereas high notes uttered a few feet distant are heard without pain, if heard at all. All sounds heard have a high pitch. My bass voice at its greatest intensity has a sharp, high sound to him. This, however, is not the case with his own ordinary voice through tissues of neck, etc., which is heard as low and distant. When he sounds either high or low notes, they are heard alike by him, and he describes them, together with my voice, as resembling the striking together of two pieces of metal.

[1] *Transactions of the American Otological Society*, vol. i., p. 106.

Tinnitus aurium is nearly always present in these cases, and in fact in most of the affections of the middle ear.

Tinnitus is not found to exist, I believe, where the membrane and ossicles are absent, and I am inclined to the opinion that it never occurs without a sound to produce it.

Many disturbances of the mechanism of the middle ear convey to the nerve a sense of sound. A patient who had the tip of a fishing-rod thrust through the membrana tympani said that the first sensation was as though a piano chord had been snapped.

In the normal condition of the ear, ordinarily, the sounds created by phonation and the circulation of the blood are not heard by the individual through tissue conduction from *within*, although others may hear them by the use of the diagnostic tube, or the individual may do so by stopping his own ears.[1]

Among the effects of the inhalation of chloroform, ether, nitrite of amyl, etc., or the use of quinia, or straining at stool, are hyperæmia of the ear, and the consequent temporary abnormity [temporary separation of the malleo-incudal joint?] which permits the sounds of the circulation to be transmitted to the auditory nerve.

The noise made by contractions of the tensor tympani muscle when the hammer and anvil are separated may, it is possible, be heard by the patient; and they may be suspected of frequent reflex excitation as the motor nerve arrives from its source in the motor root of the trigeminus through the otic ganglion.

Tinnitus cannot probably have its origin in the incompressible cavity of the inner ear. The sudden increase of blood in the labyrinth, however, could force the stirrup outward, and its return would be attended with sound; in this way we may account for the peculiar "whistling" or "whirr" which attends labyrinthine vertigo. I have sometimes produced the whistling by making active rarefaction and condensation in the meatus where some form of aural disease existed. It also occurs during

[1] For account of diagnosing tinnitus, etc., see article by J. Orne Green in these *Transactions*.

acute attacks, attended by collections of fluid in the middle ear. The condition of the conducting mechanism which occasions most of these abnormities is one *where the membrana tympani draws apart the malleo-incudal joint*, and is therefore unable to respond normally to the sound waves arriving through the meatus. The manner in which this separation takes place is explained by the mechanism of this joint, which has already been described. Sound from phonation and the circulation in the neighborhood of the ear, which has been referred to as constantly passing out of the ear without exciting the auditory nerve, is now effective upon the incus and stapes, irrespective of the membrane. The vibrations of phonation and of the circulation near the ear are conducted to it through structures which are much better conductors of sound than the air through which sound travels at the rate of 1,100 feet per second. An idea of the conductivity of bone, muscle, etc., may be formed from that of other substances. Through liquids its velocity is from 4,000 to 6,000 feet per second; through metals 4,000 to 17,000; through woods from 3,000 to 15,000.[1] It is probable, therefore, that the tissues, bone, muscle, etc., conduct sound with many times the velocity of air,[2] although it is at the expense of its definition, so to speak, from the variety of structures through which it passes, an interference resulting which depends upon the different velocities of the vibrations. This will explain the somewhat irregular character of sounds reaching the ear from within.

In making the diagnosis of these cases the tuning-fork is of much service, and if placed, when vibrating, on the mastoid process opposite the affected ear *it will be heard better, often exclusively, in the diseased ear*. Other portions of the head and face may be selected for placing the tuning-fork, but the above is believed to be the best, for the vibrations then pass through good conducting media (bone and air principally) in a direct course. When it is placed on the vertex the vibrations reach the ear from more than one direction; held between the teeth it is equally uncertain, for the sound then

[1] *Sound.* Tyndall, Lecture I. New York, 1871.

[2] *Sound.* Prof. Alfred M. Mayer, p. 73. New York, 1878.

reaches the drum through both the inferior and superior maxillary bones: by the inferior arriving mostly at the meatus through the articulation in the glenoid fossa; and by the superior reaching the drum in all directions. The fork can be used sometimes to advantage when placed on Adam's apple, or upon the chin, while the mouth is open.

But the patient's voice, as heard by himself, is the most reliable test in many instances, being a sound he is accustomed to and can describe.

Experiments with one's own ears are of advantage as illustrative of the patient's condition: Close both meatus lightly with the forefingers, and perform phonation: the vibrations, not entering the external meatus through the air in the normal manner, are *heard much louder*, for they arrive at the drum through the better conducting medium of the intervening tissues, pass *out* through the delicate drum membrane without affecting it, to be reflected from the closed meatus *back again*, with increased resonance, to the drum membrane, which is then made to perform its excursions in the usual manner. Of course the tuning-fork vibrations can be availed of in a similar manner. Tinnitus, if it exists, is also louder during this experiment.

The vibrating fork, in certain cases of deafness, is heard plainly by the patient if held in front of the open mouth; if the mouth be opened and closed rather quickly, the sound will be alternately lost and heard, giving the patient a sensation of waves of sound.

If the mouth trumpet be used on a person with normal hearing, the voice will be heard thus spoken in the mouth, if the ears are closed.

If, when double hearing exists, the air in the meatus externus be gently rarefied or condensed, with the apparatus made for that purpose, the hammer and anvil will be brought together, and the anomaly will at once cease. As soon as the operation is suspended the double hearing returns. *In these cases the membrane will usually be found more or less relaxed.*

The diseases which cause dislocation of the malleo-incudal joint may be acute or chronic, and without going into details,

which would be out of place here, it may be stated in general that tissue changes and the presence of fluids in the drum, conditions which are daily met with in aural practice, are sufficient to cause them. The tension of the membrane, when thinned, etc., is easily affected by fluids in the drum, and in acute inflammations the healthy membrane is often greatly bulged out by fluid exudations. Even a "cold in the head" may occasion striking effects: a medical man, who is very deaf, informs me that when he has a catarrhal attack of the naso-pharynx he experiences much better hearing as long as the attack is attended with discharge. In this case the tension of the membranes, which were found much relaxed, is doubtless rendered more tense by the hyperæmia excited by the nervous relationship existing between the parts affected and the ear.

A case of particular interest occurs to me in this connection. A man has had autophony in left ear for several months (following a subacute purulent inflammation of the middle ear), and in the right ear for a few days (there is now a very mild, painless, subacute inflammation of left middle ear, with minute perforation, but no pus). When the symptoms cease for a short time in the left ear he experiences a decided increase of the autophony in the right. When he speaks, the sensation in the left ear is as though he were speaking into an empty vessel; after each word there is a sort of "echo" attended with a vibratory sensation, which he compares to the rattle of the chords stretched across the bottom of a tenor drum. In the right ear this "echo" also exists, but it is "muffled." When I place the diagnostic tube in the right ear I can distinctly hear a fluid gurgling as it is agitated by the air which enters from the Eustachian tube each time he swallows or breathes. When he performs phonation with mouth and nose closed the sounds come so plainly through his ear to mine, by the conduction through the diagnostic tube, that I *am convinced there must be considerable aerial conduction through the Eustachian tube.* When the vibrations from the vocal chords leave the tissues, in this case, and pass through the medium of the right drum, which contains both air and fluid, the

sense of "muffled" hearing ensues; in the left drum, which contains only air, the sensation is like speaking in an "empty vessel."

The deafness occasioned by the presence of fluids in the drum is well known, and this condition is observed to exist to a greater or less extent in a large number of the cases referred to here, but to enlarge on this subject would be a digression.

The membrana tympani, which is so important to audition, when anomalous, becomes an impediment in some instances it would seem, as far as hearing is concerned, although frequently showing upon inspection but little evidence of disease. The perforations which exist in this portion of the mechanism are, as is well known, not always a cause of deafness themselves to any extent; and it is owing to this fact that an operation intended to establish an artificial opening in the membrane to relieve deafness has been observed with such anxiety by aurists. But probably a moment's reflection will convince any one that as sound passes through the membrane as readily as light passes through the glass slide of the microscope, it is not the presence of the membrane that prevents waves of sound exciting the auditory nerve, for sound waves, both from *without* and from *within*, have free access to the tympanic cavity; while normal audition requires that the membrane and ossicles shall make to and fro excursions as a whole. The operation proposed by Voltilini is, therefore, unnecessary. An operation for the separation of the stapes from the incus, would be far more likely to be attended with success, and could we assure ourselves that the base of the ~~latter~~ bone was free it would be in some instances advisable.

Efforts to clear up the ground here are met by great difficulties, owing mainly to our inability to examine the parts thoroughly during the life-time of the patient.

The thickening of the tissues of the drum, and their completely changed appearance, render the parts indistinguishable, the ossicles under such circumstances being often invisible. The indestructibility of the membrana tympani is sometimes very marked, and it is probably absent in a far less number of instances than is generally supposed. The same remark may

well be applied to the ossicles also; and we may conclude that entire absence of the membrane and ossicles are conditions which do not often exist; indeed, *so long as tinnitus is a symptom there is a considerable degree of action on the part of the mechanism.*

It is to be feared that the conclusions drawn from incomplete diagnoses here have been productive of great disadvantages to the progress of the pathology of this subject.

Fixation of the stapes, however, in the oval window, either by adhesions, thickening of the neighboring parts, or from action of the stapedius muscle, with or without destructive changes in the rest of the mechanism, must be a common occurrence; and although Burnett has shown that when the stapes is immovable the round window vibrates when sound enters the cavity of the tympanum, there is a doubt as to the existence of much hearing under these circumstances.

The ability to hear high tones, and not hear low ones; to hear well in a noise, and the reverse, seems to depend upon conditions of the mechanism of conduction which are simple enough of explanation; but with varying anomalies in each individual case.

Two distinct conditions appear to contribute to the abnormities of hearing: disarticulation of the malleo-incudal joint, and alterations in the tension of the membrana tympani. In the dislocations above mentioned it requires a more or less heavy impulse, as the waves occasioned by the discharge of artillery or the concussion of thunder, etc., to force the membrane in far enough to form a close connection between the hammer and anvil, — the lesser displacements yielding to sounds of less amplitude. Burnett has shown that for deeper notes longer excursions are made. In cases of so great a degree of deafness as to require the shocks of thunder to excite the auditory nerve, the effect is usually painful. Where the membrana tympani is greatly relaxed (with possibly more or less separation of the hammer and anvil) the low shocks of a railway train in rapid motion will overcome the difficulty. The tick of a watch appears to be best heard in cases where the membrane retains its tension. By rendering the membrane

tense by Valsalva's experiment, the excursions of great amplitude (as when on a railway train in rapid motion, on the noisy pavement, or in the presence of an orchestra while it is performing) are prevented reaching the auditory nerve. Whistles, bells, piccolo, flute, etc., however, are still heard. If the distention is carried to a painful extent the high tones are finally heard less distinctly.

It is well known that the hearing of some persons is affected by a moist or dry state of the atmosphere; which may be explained by the varied tension of the membrane produced by these conditions.

The too free entrance of air into the drum with the acts of respiration, swallowing, or yawning, although not affecting very much the normal membrane, may occasion great variation in the hearing of those affected with a dislocation of the hammer and anvil or a relaxed membrane. Atrophied membranes seem to be exceedingly distensible, whereas in the normal state they are known to be inelastic. A consequence of elasticity is that the membrane does not readily move as a whole in response to ordinary vibrations of sound.

Patients with a relaxed membrane are likely to experience a crackling sensation when performing the acts of respiration, swallowing, or yawning, as the air entering the drum drives the membrane outwardly. The experiments of Politzer or Valsalva produce most unexpected effects on the hearing of these patients, greatly increasing the hearing of some for a short time, and making others very deaf; if repeated for a length of time, these operations are likely to render the membrane more relaxed, and thus increase the difficulty.

In conclusion, a few remarks concerning the inner ear may not be inappropriate to the subject.

The auditory nerve, it would seem, has only the power to perceive sound when its terminal fibres are irritated, not to produce or modify it in any way.

When exhausted or long disused it probably undergoes pathological, not physiological changes.

The question as to the ability of the inner ear to analyze sound may be relegated to the field of psychology; but that it

can perceive every variety of sound, as the phonograph does, may be regarded as a fact; and although we may not be able to determine how the nerve perceives sound, we may well believe that cultivation has much to do with the perfectly developed perceptive faculties of the brain.

Grave diseases of the inner ear are not infrequent, and the auditory nerve is thus sometimes impaired; but too great importance has perhaps been given the affections of this portion of the ear, especially as regards the acoustical anomalies.

The occurrence of sudden deafness during the progress of constitutional affections is frequently ascribed to some lesion of the inner ear, although we know that a very slight appearing abnormity of the mechanism will disturb transmission of sound to the auditory nerve, even to the most profound degree.

Acute inflammations of the middle ear, it would seem, from continuity of surface, are more likely to affect the inner ear than invasions from the brain, and they are in fact of far greater frequency. Strict examination often indicates that deafness attributed to cerebro-spinal meningitis has most probably arisen from acute (painful) middle-ear affections.

The sudden deafness of syphilis has, beyond doubt, its principal seat in the conducting mechanism, for in all these cases which I have examined, *the vibrations of the tuning-fork, when placed on the head, are transmitted through the tissues to the auditory nerve, and are heard; and the patient can hear distinctly his own voice.*

The deafness from falls, blows upon the ear, etc., may mostly be attributable to lesions of the conducting mechanism; certainly greater knowledge upon this subject will refer fewer of them to the region of the inner ear.

This paper gives the results of much observation and thought on audition by one whose work is done in the midst of a busy life, in the hope that, from a pathological stand-point, he may contribute a few grains of truth to the specialism which has for him so much attraction, but he by no means intends to trespass upon the grounds of physiology or ignore the results of its labors.