

an abscess from a tumor, we have, in favor of the former, a distinct etiological cause in the aural suppuration, and more or less fever and a remission of the head symptoms; while, in the case of a tumor, there are an absence of cause, rarely any fever, and a steady increase in the head symptoms without remission. In children tuberculosis of the brain, associated with suppuration of the ear, may render the diagnosis very difficult; but brain tubercles are usually multiple, and symptoms which can only be referred to several different situations point to the presence of tubercles, while symptoms which point to the disease solely in those parts of the brain where otitic abscesses usually lie render an abscess probable.

Injuries of the cerebral nerves are common with leptomeningitis, not infrequent with brain abscess, and common with tumors, but with extradural abscess they are rare and are confined to the seventh and fifth nerves.

PHLEBITIS OF THE SINUSES OF THE DURA AND OF THE JUGULAR VEIN is less common than simply pachymeningitis, but more common than leptomeningitis and brain abscess. It occurs usually in the lateral sinus, being due to an extension of inflammation from an extradural (perisinous) abscess in the posterior fossa, but it occurs occasionally only in the superior petrosal sinus, in which case it is due to a collection of pus upon either the posterior or the superior surface of the petrous bone; it also occurs, though very rarely, in the inferior petrosal sinus only, and is then due to suppuration in the labyrinth or to caries at the apex of the pyramid. In the case of the jugular vein it is almost always due to extension of phlebitis from the lateral sinus. Phlebitis of the cavernous sinus is always associated with, and caused by extension *ex continuo* from, phlebitis of the lateral sinus. It is not unusual for all of these sinuses, together with the jugular, to be involved secondarily by extension from a primary phlebitis of the lateral sinus. It is rather the rule than the exception for these phlebitides to be complicated with the other otitic intracranial diseases of which pachymeningitis is the most frequent. The bone is diseased in immediate contact with the dura in eighty-two per cent. of the cases (Körner); and the diseased bone is on the inner wall of the mastoid, usually in the sigmoid groove.

Symptoms are dependent upon the stage of the pathological process, upon the phlebitis and thrombosis, upon suppuration of the thrombus, and upon stasis of blood within the brain.

The phlebitis alone gives no symptoms; the thrombus may exceptionally obstruct the circulation in the veins which drain into the sinus, but a collateral circulation is so soon established that these symptoms are generally absent. From obstruction of the mastoid emissary we may have swelling and edema just behind and below the mastoid process; from obstruction of the cavernous sinus we may have congestion of the ophthalmic veins, choked discs, edema of the eyelids and conjunctiva, protrusion of the eyeball, and congestion of the vena frontalis; and from the periphlebitic swelling we have, very rarely, paralysis of the oculomotorius (third) or of the abducens (sixth), or neuralgic pains in the trifacial (fifth). From obstruction of the jugular there are often cording of the vein, swelling and edema of the tissues and glands about the vein, and cellulitis of the neck; very rarely, from the periphlebitic swelling at the jugular foramen, there is paralysis of the glossopharyngeus (ninth) or of the pneumogastric (tenth).

The suppuration of the thrombus usually gives the characteristic symptoms of the disease. These are generally well-marked pyemic and septicæmic symptoms; well-defined rigors (one or more); high temperature (104° to 106° F.), remitting or intermitting several times a day, even falling to the normal. Metastatic infarcts are most frequent in the lungs, for the emboli are seldom small enough to pass these organs; but occasionally they are found in the spleen, the joints, or the muscles. Not all emboli are necessarily infected, however, and non-infected infarcts without abscesses occur. Metastatic abscesses in the lungs are usually in the periphery of these organs, and multiple, giving the symptoms of a profuse bronchial catarrh; they often break into the pleura and

give an empyema. It is said that non-infected infarcts may produce bloody sputa.

The Stasis of Blood within the Cranium may give headache, either diffuse, or unilateral on the affected side; vomiting, especially in the beginning of the disease; congested papillæ and optic neuritis, although these are not so common as was formerly thought; nystagmus, particularly on turning the eyes away from the diseased ear; psychic depression; and occasionally delirium, but serious disturbances of consciousness are unusual.

Diagnosis.—Pyæmic symptoms, chills with sharp variations in temperature, during a suppuration of the tympanum, either acute or chronic, immediately suggest involvement of the sinuses. Inflammatory symptoms in the mastoid are confirmatory; and if, on opening the mastoid, its inner wall is found to be inflamed and exposure of the dura at this spot fails to discover a large extradural abscess, the diagnosis of sinus disease is almost certain. Cording of the jugular is a sure indication of the disease and occurs, according to Jansen, in one-third of the cases. Leucocytosis I regard as of no diagnostic value, for I have found that it is present in nearly eighty per cent. of uncomplicated tympanic suppurations.

Sinus-phlebitis alone, without other intracranial disease, is found in less than half of the cases; it is usually combined with pachymeningitis and occasionally with brain abscess, and consequently the clinical picture is often bewildering till opening of the bone reveals the path of inflammation from the ear to the sinus. Sometimes a natural cure takes place by a connective-tissue obliteration of the sinus. J. Orne Green.

EAR DISEASES: MASTOID OPERATIONS. See *Mastoid Operations.*

EAR DISEASES: METHODS OF DIAGNOSIS.—The condition of each part of the ear may be determined with a fair degree of accuracy after a careful consideration of the subjective and objective materials at hand, notwithstanding the fact that the internal ear is entirely beyond the range of vision and that when it is in its normal condition but little can be seen of the middle ear. The examination of the ear is logically divided into the subjective examination, which includes the history and the tests for hearing, and the objective examination.

The subjective examination embraces the investigation into the history of the case and the carrying out of the hearing tests both for the ear as a whole and for the perceptive apparatus alone.

In ascertaining the history of the case it is important to learn what is the most prominent symptom complained of, whether one or both ears are affected, and if both, which of the two seems to be the more seriously involved. In chronic cases, when but one ear is complained of, it will often be found that both are affected though in different degrees. It is well to examine the better ear first so as to ascertain the normal direction and shape of the canal and thus facilitate a comparative test.

The duration of the affection is of importance in determining the prognosis as well as the diagnosis. The shorter the duration the better the prognosis, as a rule. The time of onset may usually be determined with accuracy in the acute cases, for these date from a "cold," from a traumatism, from one of the exanthemata, from typhoid fever, from influenza, from the expansion of a mass of cerumen, or from the introduction of a foreign body or the hatching out of maggots; while in the chronic cases, especially in those belonging to the sclerotic form of otitis media, the disease may, owing to its insidious onset, exist for a long time before its presence is noticed by the patient. The origin in such cases is often dated from the time when the tinnitus made its appearance. In other cases, however, the patient discovers by chance, long after the true onset of the disease, that he is hard of hearing in one ear. Thus, for example, he may, while lying on the good ear, miss certain familiar sounds, as the ticking of a clock. There are cases, furthermore, in which both ears have been insidiously growing hard of

hearing for a long time, but in which the patient does not become aware of his deficiency until he finally observes that he has considerable difficulty in carrying on a conversation. In still other cases the patient's attention is first drawn to his ears by the development of tinnitus or by the aggravation of the defective hearing that follows a "cold." In the early stages of hardness of hearing the patient frequently complains of a confusion of words when in company; he can hear one speaker very well, but, when several are talking at the same time, he cannot distinguish the words.

The probable cause can in many cases be ascertained from the answers given by the patient, and such knowledge is often a decided aid to diagnosis. The important points to be learned are: (a) whether the affection is due to any cause which affects the ear directly, as cold, traumatism, scalds, burns, frost-bite, explosions, fungi, or insects; (b) whether it is the sequel of some general malady, as one of the exanthemata, influenza, smallpox, syphilis, tuberculosis, diphtheria, gout, mumps, rachitis, malaria, whooping-cough, or some one of the numerous diseases of the nervous system, the lungs, or the circulatory apparatus; (c) whether it is the effect of some drug—usually quinine or the salicylates; or, finally, (d) whether it is a result of heredity, which, in the ear as in other diseases, often skips a generation. Unfortunately, there are many cases in which the cause cannot be traced.

Earache or pain, if present, is usually the most prominent symptom. If it develops in an ear that has previously been healthy, it indicates the existence of an acute inflammation of the middle ear or a furunculosis of the external auditory canal; if it occurs, on the other hand, during a chronic process, it very probably signifies the spreading of bone caries, or the damming up of pus, or the pressure caused by a cholesteatomatous mass. Pain may at times be purely a reflex otalgia dependent upon carious teeth or upon some inflammatory process in the pharynx or tonsils, or it may in reality be a part of a trifacial or a cervico-occipital neuralgia. It may or may not be present in mastoiditis. Careful observation of the objective signs will often determine the origin of the pain. Thus, for example, pain caused by pressure on the tragus or due to drawing on the auricle indicates an inflammation of the auditory meatus; the presence of tenderness in the depression below the lobule indicates an otitis media; while a tender mastoid indicates the existence of an inflammation in the interior of that bony prominence.

Subjective ear noises (tinnitus aurium) occur in two-thirds of all ear cases, according to Politzer. They are probably due to pressure and irritation of the nerve endings in the labyrinth. Ear noises are variously described as singing, ringing, blowing-off of steam, hissing, rushing, roaring like the waves of the seashore, certain musical notes, clicking, or voices. In some cases the noises are heard only during perfect silence, as after retiring or when the patient is reading alone. They are especially marked when the patient is fatigued, or during a "cold," or when his general condition is below par. Noises are more common in the sclerotic form of chronic middle ear catarrh than in the chronic suppurative conditions. In the sclerotic cases the tinnitus is frequently described as a singing or a blowing sound, and here it often precedes the deafness by many years, if indeed the latter ever follows. Tinnitus may occur in cases of aspergillus or of impacted cerumen, or it may follow the use of quinine or the salicylates. When it is due to drugs it is evanescent and probably is caused by anæmia of the labyrinth. If the noises are diminished by compression of the carotid artery they are probably caused by congestion of the arterioles in the middle or external ear, and in such cases they are often synchronous with the pulse. The clicking or crackling forms of noises are generally due to spasm of the palatal muscles acting on the Eustachian tube and causing separation of its sticky walls. They may also be due to spasm of the tensor tympani or the stapedius muscle. In a certain number of cases these noises may be heard by the examiner as

well as by the patient. When the subjective sounds are sustained musical notes they usually represent the high A of Beethoven. Hysterical patients may describe the subjective musical sounds as "entire operas." Voices are rarely heard except in insanity. A small epithelial scale attached to the drum membrane has at times been the sole cause of distressing subjective noises. When the tinnitus intermits the prognosis is more favorable than when it is constant.

Dizziness or vertigo is occasionally due to pathological conditions in the ear. This symptom suggests hemorrhage in the labyrinth, especially when accompanied by the chain of symptoms described by Ménière (tinnitus, nausea, vomiting, and depression). Dizziness may be a symptom in any ear disease in which there is pressure upon the membrane of the oval or of the round window, which pressure is in turn transmitted to the nerve endings. Thus, fluid in the middle ear may be a cause, or there may be increased tension of the ossicular chain in consequence of adhesions or of an increase in atmospheric pressure upon the tympanic membrane (from occlusion of the Eustachian tube). Vertigo has also been set up by syringing the ear, or by pressure made with a probe upon the free stapes, or by inflation of the middle ear. Vertigo may be a symptom of meningitis with ear involvement. It must be remembered, however, that vertigo from brain or other lesions may coexist with an independent affection of the ear. Impacted cerumen has been known to cause vertigo.

Discharge.—The character and duration of a discharge are important diagnostic factors. The discharge may indicate an otitis media, a furunculosis, an otitis externa diffusa—either simple or complicated by aspergillus,—or a fracture of the temporal bone. Should the onset of the disease be sudden, as after a cold, bathing, or one of the acute diseases mentioned above as causes; should it be accompanied by pain and by a clear or blood-streaked serous discharge; and, finally, should the pain cease as the discharge begins, an acute otitis media may rightly be suspected. A discharge that commences without pain and becomes purulent in character, indicates a tuberculous condition, especially if multiple perforations of the membrana tympani are found. The quantity of the secretion varies greatly in different cases. Thus, in diffuse otitis externa or in furunculosis it is usually slight in quantity, while in scarlet fever, in diphtheria, in influenza, in bone caries with granulations, and in mastoiditis, it is generally excessive. It is often bloody in the different forms of cachexia, in leukæmia, in cases of traumatism, and in persons in whose ears there has been a post-diphtheritic erosion of an artery. In bone caries the discharge often resembles meat washings, or else it is like serum and irritating in character. In fractures of the base, and at times after operation on the stapes, there is an excessive serous discharge, which rapidly fills the meatus if it is not firmly packed. The presence or absence of odor does not throw any light upon the question whether bone caries is present or not, for the unpleasant smell simply indicates that there is retained discharge which is undergoing decomposition. The discharge may be continuous or it may intermit. Periodical brief discharges preceded by a pain indicate attic trouble, and a perforation of the membrana flaccida should be looked for. The color of a chronic discharge may be modified to any shade and it may contain detritus and numerous cocci, bacteria, and vibriones, together with epithelial scales when cholesteatoma is present. In some cases the objective examination reveals cicatrices, perforations, or adhesions, all of which lesions indicate that a discharge has existed at some previous time. Thus, for example, the small perforations which are found in Shrapnell's region, and which were formerly referred to as the foramen of Rivini, represent the remains of such a pathological process. After long-standing chronic suppuration much destruction of tissue may be expected. Thus, for example, large perforations in the drum membrane, and caries, or even the complete disappearance of the ossicula and neighboring bony parts, may be found.

Other symptoms commonly complained of are: stuffiness and a full feeling or a sensation of pressure in the ear. In addition to the special points presented above, brief consideration may be given to the more general subjects of *vocation* and *habits of life*. In the case of persons who are exposed to all weathers or who are working in damp, dusty, over-heated, draughty or very noisy places, or who lead sedentary lives or have vicious habits, a more guarded prognosis as to a speedy recovery from ear disease must be given. Auditory nerve lesions are especially apt to be detrimentally affected by noises. It is well to remember that ear affections are more frequent in early childhood and in late life, that they are more common in men than in women, and that the left ear is more frequently involved than the right. About one-fourth of all ear diseases are found in the external ear, sixty per cent. in the middle ear, and eight per cent. in the internal ear. Painful sensations (*hyperesthesia acoustica*) are sometimes found in nervous people, especially in cases of slowly progressing nerve deafness. *Autophonia* or *tympanophonia* is met with when the walls of the Eustachian tube are swollen or when there is impacted cerumen in the external auditory canal. In this condition the patient's own voice sounds as if he were talking in a barrel. *Paracusis Willisii*, or hearing better in a noise, is found more often in the sclerotic form of chronic otitis media and is therefore an unfavorable symptom; *Paracusis localis*, or inability to locate the direction from which a sound comes, is found in marked unilateral deafness. Sudden loss of hearing is a common phenomenon in impacted cerumen, but it also often means labyrinthine syphilis. At times the pitch is altered in one ear; this is an annoying symptom in musicians and usually occurs in disturbances of the inner ear; the affected ear can be detected by holding a fork of known pitch alternately in

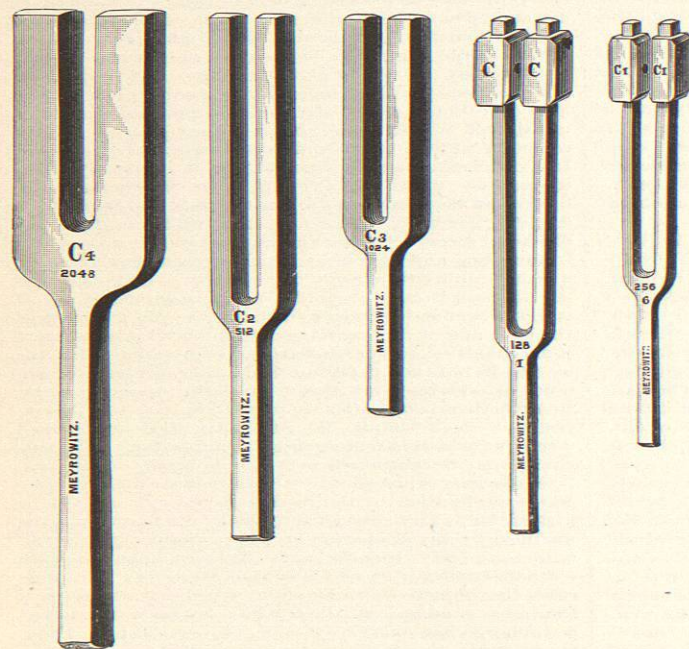


FIG. 1787.—Hartmann's Set of Tuning Forks.

front of each ear and having the patient imitate the sound. These cases are usually characterized by the circumstance that there is increased pressure upon the stapes in the fenestra ovals.

TESTS FOR HEARING.—The hearing should be tested: first, as a whole; second, as to the perceptive apparatus alone. In testing the hearing it is customary to employ the voice (words spoken in the ordinary tone and whispered), a watch which is heard in the normal ear at from fifty to seventy inches, a small clock normally heard from forty to fifty feet, a set of Hartmann's tuning forks, and a Galton whistle. Many other devices have been suggested, some of which are ingenious and of value to the expert. Amongst the latter may be named the universal acoumeter of Politzer, the sonometer of Hughes, the tuning forks of Blake, Luce and Dench, König's cylinders, and Appunnes' apparatus for determining the upper tone limits, all of which are fully described in the more comprehensive works on this subject. The normal human ear varies in its capabilities of detecting sounds, not only in different people but in the same person under different conditions. As a rule, tones of from sixteen to thirty-three thousand vibrations may be distinguished by the ear, but only those of from forty to four thousand vibrations are pleasing or musical; and the range of musical tones which the voice is capable of producing, is limited to those of from fifty to eighteen hundred vibrations.

In treating of the hearing power as a whole, we may conveniently consider the subject under the two heads of (a) intensity and (b) pitch.

Intensity is most conveniently tested by a watch, clock, acoumeter, sonometer, or voice. The voice is useful to the expert, but the beginner will find the watch more practical. Each ear should be tested separately. The one not being tested should be closed by a moistened finger tip, and the eyes should be closed in order to eliminate any psychological element. The patient should first be allowed to hear the character of the sound used in testing, and then the watch should be held in a line perpendicular to the auricle, at a short distance beyond the normal hearing power, and should be gradually approached to the ear until it is heard. The hearing distance is expressed by a fraction the numerator of which is the distance at which the watch is heard by the patient under examination, and the denominator the distance at which the watch should be heard normally; thus A. D. W. D. $\frac{2}{3}$ would indicate that in the right ear the watch distance is one-half of the normal; or, in other words, since sound varies as the square of the distance, that the hearing has been reduced one-fourth. This distance may be expressed in inches or feet. Should the watch be gradually withdrawn from the ear to the farthest hearing limit, the fraction will be greater than when the above method is used, for the probable reason that the nerve endings having once been set in motion tend to continue so, while if at rest they require a louder noise to overcome the inertia and start them vibrating. It must be remembered, in this connection, that the watch may not indicate changes in the hearing power with accuracy, because while the hearing for other tones may be modified, it is possible that hearing for the tones of the watch used might not change. When the voice is used for this test the "forced whisper" from a full chest is best for com-



FIG. 1788.—Galton Whistle.

parative purposes, and, instead of fixed sentences, numbers of two figures should be used. The phonograph of Gradenigo and Urbantschitsch need simply be mentioned in this connection as having been suggested for this purpose.

Errors in pitch are tested by tuning forks, the Galton whistle (Fig. 1788), and other musical instruments. Hartmann's set consists of five tuning forks (Fig. 1787), as follows:

	128 vibrations per second for the pure tone.
C.	256
C'	512
C''	1,024
C'''	4,096

This set is used by Schwabach in his test. On the other hand, a very accurate diagnosis may be made by using the following instruments: a low-pitched fork, C-1, to determine the low-tone limit (or errors of the conducting apparatus); a higher-pitched fork, as C'', for determining the Schwabach, Weber, and Rinne tests (absolute bone conduction); and the Galton whistle, for determining the upper-tone limits or disturbances of hearing due to disease of the receptive apparatus. The tuning forks should be struck on a moderately soft substance (e.g., wood, covered with leather), in order to avoid the formation of over-tones. The clamps shown on the C and C' forks are used in order to prevent these. Galton's whistle is employed for the purpose of testing the ability of the auditory nerve-fibres to distinguish tones ranging from 6,481 vibrations per second to the highest perceptible tone limit. This apparatus (Fig. 1788) consists of a steel tube of a given size in which air is caused to vibrate by means of a rubber ball fitted to one extremity, while the length of the tube may be regulated by turning the milled head at the other end. The note produced by it will become higher and higher as its length is diminished. In other words, the Galton whistle acts as a closed organ pipe in which the column of air is set in vibration and whose length may be varied at will.

The following rules, although they cannot be trusted implicitly, are of much diagnostic value when taken in connection with other points: 1. In hardness of hearing originating in the conducting apparatus low tones are often lost while high tones are usually heard well. For example, in this form of deafness thunder may not be heard while the voice is heard fairly well. In other words, the low-tone limit is raised. 2. In diseases of the receptive apparatus the high tones are lost or the high-tone limit is lowered while low tones are heard well. In such cases conversation is heard fairly well while the watch is very poorly heard. In certain diseases, in which there is increased pressure on the auditory nerve, both high and low tones may be lost while middle tones are heard fairly well.

By applying the above rules to the results obtained by the forks named (C-1 or Dench adjustable fork for low tones, and Galton whistle for high tones), the condition can be diagnosed.

Testing the Hearing Power in the Perceptive Apparatus Alone.—Among the tests used to determine whether the defects in hearing are due to nerve lesions or to alterations in the conducting apparatus, are those of Weber, Rinne, Gellé, Bing, Schwabach, and Gradenigo.

The Weber test consists first in holding the handle of the tuning fork (512 vibrations or lower) on the median line of the skull or against the incisor teeth or the symphysis of the mandible; then, if the vibrating fork is best heard in the deaf ear, the trouble is in the conductive apparatus and if best heard in the better ear the trouble is in the perceptive apparatus.

Rinne's Test.—Rinne first ascertained that the normal ear heard the vibrating tuning fork through the air—i.e., when the fork was held before the ear—about twice as long as when its heel was pressed on the mastoid process—i.e., when the vibrations were transmitted through the bone. He found, however, that when the conducting apparatus is obstructed, the vibrations can be heard longer and longer with the fork in contact with the mastoid than

through the air. In the Rinne test, therefore, the vibrating fork is held alternately before the ear and in contact with the mastoid process; and if the sound of the fork is heard louder and longer through the air than through the bone, in a partly deaf ear, it is permissible to infer that the lesion is located in the perceptive apparatus. On the other hand, if, in a similarly deaf ear, the sound is heard better through the bone, it may rightly be concluded that the lesion is in the conductive apparatus. The C' tuning fork is commonly used for this purpose because if properly made it is free from over-tones. When the loss of hearing is slight the watch may be used, and if its ticking is heard when it is placed on the mastoid, between the teeth, or on the forehead, and not heard in front of the ear (through the air), the defect of hearing—it may be inferred—is in the conducting apparatus.

Gellé's test is for the purpose of ascertaining the mobility of the stapes in the oval window. It depends upon the fact that, if the foot plate is movable, compression of the air in the external canal will cause the sound from a vibrating tuning fork held on the skull to be diminished or lost, while if the foot plate is not movable there will be no change in the intensity of the sound.

Bing's test is a modification of Weber's. Schwabach's test consists in measuring the actual time of hearing each of the different vibrating forks on the mastoid and before the ear, tabulating these periods of time and applying the rules given above. Schwabach uses, in making this test, the five Hartmann's forks.

In nerve deafness the conduction through air is better than that through bone, although the absolute duration of both is reduced. Bone conduction is usually decreased in the aged, as the auditory nerve is then somewhat defective. In all tests for bone conduction diseases of the external ear should be eliminated by inspection.

The vibrating tuning fork C' has been used, according to the suggestion of Politzer, as a means of testing the permeability of the Eustachian tube. For this purpose the vibrating fork should be held in front of the nostrils during the act of swallowing. If the sound is then heard better in one ear, the opposite Eustachian tube is probably closed. In this test, however, the fork may be heard better in the worse ear if it happen to be the seat of a sclerotic otitis media with an open tube.

THE OBJECTIVE EXAMINATION.—The objective examination consists of a careful inspection of the periotic region, the external ear, and as much of the middle ear as is visible. This is done with the aid of a strong light and certain instruments of precision, and confirms the subjective examination.

Inspection by the naked eye, aided by concentrated light, should detect any skin lesions (eczema, furuncles, etc.), errors of development, traumatism, tumors or new growths, and variations from the normal color. By the aid of palpation any tenderness, boggy, or fluctuation may be detected. Tenderness from pressure on the tragus would imply inflammation of the meatus, while the same sensation caused by pressure made below the lobule would point rather to inflammation of the middle ear. Tenderness over the mastoid indicates inflammation in that region. So too palpation is competent to determine the consistence of tumors or swellings. A rigid, cord-like swelling along the anterior border of the sterno-cleido-mastoid muscle is one of the important signs of sinus thrombosis.

Illumination.—Daylight or artificial light may be used, either directly or indirectly. Daylight, when obtained from a light cloud, is excellent, but, inasmuch as it is available only at certain times, it cannot be depended upon. Direct light may be used in the ear in emergencies when there is no mirror at hand, but its value, except for the examination of external parts, is small. Indirect artificial light furnishes the form of illumination most commonly employed. The source of light may be a candle (or, what is better, three candles), a kerosene lamp, gas, or an electric light. The Welsbach light is the better form of gas light. When any artificial light is used allowance must be made for the changes in color due to the source.