as a last resort the mastoid may be opened (Schwartze), in cases in which the disease is pent up in the tympanum or in which it is apparently extending inward.

SARCOMA.—Cases are on record in which sarcomatous growths, both primary and secondary, have been observed in the middle ear. They are more apt to be found in childhood, and are usually of rapid growth. In their early stages they generally resemble ordinary polypi, but, unlike them, they recur quickly after repeated excision.

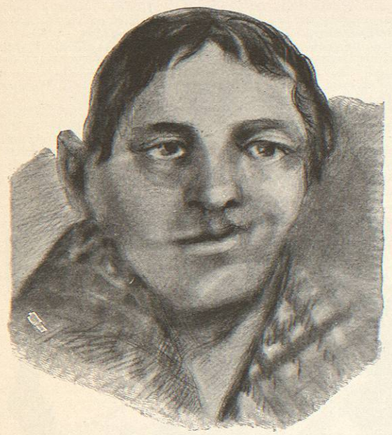

FIG. 1803.—Carcinoma of the Temporal Bone. (Case of Dr. Gorham Bacon.) From a photograph.

As in the case of carcinomata they are apt to follow chronic inflammatory conditions. The discharge may be bloody, very offensive, and purulent. In the later stages there may be paralysis of the facial, the abducens, or the first division of the fifth nerve, in association with meningeal or brain symptoms or severe hemorrhage from erosion of the large blood-vessels in the neighborhood.

MALIGNANT GROWTHS OF THE INTERNAL EAR.

In the labyrinth, as in the middle ear, malignant new growths are more apt to be secondary than primary. Very few of the cases of primary growth in the labyrinth have been fully enough reported to possess any clinical value. Sarcoma, neuroma (glioma), and carcinoma have been reported. Virchow has shown that the auditory nerve is more often the seat of new growths than is any other of the cranial nerves. Politzer reports a case of carcinoma of the labyrinth in a man aged forty-seven years. In this case the growth originated in the mastoid region, spread through the middle ear to the cochlea, and thence through the internal meatus to the brain. Death occurred through erysipelas. New growths, however, are more apt to reach the auditory nerve and labyrinth from the cranial cavity, and in most instances they are primarily carcinomata of the dura or of the brain itself. Burkhardt-Merian (*A. f. O.*, Bd. xii.) reported the finding, post mortem, of a fibro-sarcoma in a man, aged sixty-six, who had died of pneumonia. This had originated in the termination of the inferior petrosal sinus and had passed thence by two tracks into the labyrinth—one through the aquæductus cochleæ and the other below the internal auditory meatus, around the cochlea, to the tunica adventitia of the carotid artery. Field has reported a sarcoma, the size of an orange, on the posterior surface of the petrous bone, which had originated in the dura and had destroyed the auditory nerve.

Moos (*A. f. O.*, Bd. iv.) has reported a case of spindle-cell sarcoma which was as large as a walnut and situated externally to the left internal auditory canal. It was connected with the cerebellum and pushed the medulla oblongata over toward the right; the auditory nerve entered into the tumor but was speedily lost among its component tissues; and a second tumor, the size of a pea, was found in the dilated internal auditory canal. The cervical and dorsal portions of the spinal cord were degenerated, as was also the labyrinthine portion of the auditory nerve. This case occurred in a woman, aged forty-five, who died of suffocation one year after a sudden attack of vertigo, deafness, ptosis, lachrymation, and headache.

George C. Stout.

EAR DISEASES: OPERATIONS UPON THE TYMPANIC MEMBRANE AND OSSICLES.—Operations upon the drumhead and ossicles and within the middle ear are usually done through the natural channel of the external auditory canal; when this canal does not permit a sufficiently free access to the operative field, it is necessary to reflect the auricle forward by means of a curvilinear incision through the integument and underlying soft tissues; this necessity is of comparatively rare occurrence, for, even when the external auditory canal is much narrowed, it is possible, under good illumination and with the exercise of an educated tactile sense, to do the majority of middle-ear operations through the natural channel.

In all operations involving the opening of the tympanic cavity, especially those applied to the relief of conditions incident to non-suppurative disease, sterilization of the canal, of the auricle, and of such parts of the head and neck of the patient as may come in contact with the hand of the surgeon, is an important prerequisite. To this end, the auricle, and the skin about it, should be thoroughly washed with soapsuds (green soap) and afterward with alcohol, and, if the sterilization is done the night before operation, the parts mentioned should be covered with dry baked gauze; at the time of operation, a sterilized towel should be pinned over the head and another over the neck and shoulders of the patient. The external auditory canal should be carefully cleansed of cerumen and epidermis, preferably by means of a moist, cotton-tipped probe, and this should be followed by a similar swabbing with either the peroxide of hydrogen or alcohol, care being taken, if this cleansing is done shortly before operation, to avoid maceration of the outer coat of the drumhead, or to increase unduly the circulation. In emergency operations, such as incisions for phlebotomy or to give exit to fluid, when the more thorough precautions of sterilization are not possible, it is still important to have the hands of the operator and the instruments and dressings which he uses sterile, and to avoid contact of the former with the patient and of the instruments with the walls of the canal.

The simple operation of incising the drumhead is usually done for the purpose of relieving blood pressure or of evacuating the fluid contents of the middle ear, contents which may vary in quantity from a few drops to a body of fluid sufficing to fill the whole tympanum, and in consistence from the thinness of fresh serum to the thickness of inspissated mucus.

The point usually chosen for paracentesis, for the evacuation of fluid, is the posterior inferior quadrant of the drumhead, the incision varying in size from that of a simple puncture to a cut of two or more millimetres in length made from below upward and parallel to the peripheral line of the drumhead. For purposes of phlebotomy, in cases of acute congestion in the epitympanum, the incision is usually made along the posterior superior periphery, from below upward, ending at or near the short process of the hammer and capable of penetrating

to the deeper layer of blood-vessels in the inner tympanic fold.

After incision, in such cases, the ear should be wiped dry and plugged at the meatus with a piece of sterile cotton, or the canal should be filled with a loosely rolled absorbent cotton wick extending as far out as the entrance of the canal; over this and filling the concha, a second piece of cotton should be placed, directions being given for its renewal when thoroughly moistened by the outflow from the ear, fresh cotton then being applied externally but the drainage wick being allowed to remain in place for several hours at a time and changed only under conditions of careful sterilization of the hands which roll the wick and of the instruments which introduce it.*

If the fluid to be released from the middle ear is thick and tenacious, a larger incision in the drumhead is required than when it is thin and flows freely; evacuation may be assisted by auto-inflation of the middle ear, by Politzerization, by the use of the catheter, or by means of the pneumatic speculum and suction. When the secretion is so thick that only a small bead-like portion extrudes, this may be touched with a weak solution of nitrate of silver on a cotton-tipped probe, the resulting coagulum affording a hold to the forceps by means of which the tenacious mass may be withdrawn.

Forcible inflation of the middle ear after paracentesis for the relief of acute congestion or the release of the products of acute suppurative inflammation is contraindicated.

In the two classes of cases demanding the more extensive operations upon the drumhead and within the middle ear, the operations are more distinctly differentiated in their purpose than in their method of procedure.

In suppurative middle-ear disease, operation is usually undertaken with a view to affording exit to morbid products and permitting access to diseased parts for purposes of removal or of curative application, the betterment of the hearing being a secondary consideration. In non-suppurative middle ear disease, operative interference is usually undertaken as a measure of last resort, for the relief of a high grade of impairment of hearing or of the concomitant symptoms due to immobility of the sound-transmitting apparatus in the middle ear.

In all middle-ear operations, but especially, of course, in non-suppurative cases, conditions of sterilization should be strictly observed, and the more uniformly these are insisted upon by the surgeon, both for himself and his assistants, the more definitely do they become fixed as an important and necessary habit.

A common result of suppurative middle-ear disease is a persistent opening in the drumhead, and if the middle ear has become dry and the mobility of the ossicular chain is comparatively unimpaired, closure of the opening effects an improvement in the hearing. This is easily tested by covering the perforation with a disc of moistened paper, and if the result is favorable, the paper may be used to assist in the permanent closure of the opening.

The edge of an old perforation of the drumhead consists of a thin line of cicatricial tissue or of a union of the outer, dermoid, and inner, mucous, coats in the form of a transition membrane; both of these structures are inimical to proliferative growth and must, therefore, be removed. This is done preferably by means of a thin-bladed knife, the cut edges are then wiped dry, and a disc of thin, sized paper is floated and moistened in a weak corrosive solution, picked up on a cotton-tipped probe, and gently applied over the opening; immediately upon contact with the dry, warm surface of the drumhead the paper leaves the wet cotton tip and adheres to the membrane. By manipulation and by patting with a dry, cotton-tipped probe adhesion is favored and the superfluous moisture is absorbed. Inflation of the ear for at least twenty-four hours after application of the paper should be avoided.

The stiff, adherent paper not only pulls upon the rim of the perforation with every major vibration of the drumhead, causing an irritation which stimulates new growth, but serves as a protection and a guide along which the nascent tissue progresses. This application has been found serviceable not only in the healing of smaller perforations (one dressing alone sometimes sufficing), but also in the building up of larger cicatrices when a principal portion of a drumhead has been destroyed, and when it has been necessary to apply the paper to successive portions of the perforation rim and to occupy several months in the entire healing.

As after-results of suppurative middle-ear disease, there may be thickening of the mucous folds in the epitympanum, the formation of adhesions limiting the movements of the ossicles, and of cicatricial membranes growing inward from the edges of the perforation of the drumhead and interfering with the transmission of sound. The common locations of adhesions are between the long process of the malleus and the inner tympanic wall and around the stapes and into the fenestral niche, while the thickening of the reduplications of mucous membrane, normal in a large majority of middle ears and often filling the lower limit of the epitympanum, serves to keep the ossicles in the abnormal position into which they are drawn by contraction of the tensor tympani muscle exerted when the counter-balancing tension of the drumhead is removed by perforation.

The extension of a cicatrix from the posterior edge of a large perforation of the drumhead inward upon the inner tympanic wall will sometimes enclose the round window in an individual space. Under this condition, absorption of air in the enclosed space or the exudation of fluid into it will so far impair the movement of the membrane of the round window as to still further decrease the hearing, puncture or incision of the cicatrix being required.

In all tentative operations for improvement of hearing by division of adhesions and mobilization of the ossicles, if the suppurative process has run its course and the ear has become dry, it should be remembered that there is a possibility of awakening acute trouble, and that, unless complete evulsion of the larger ossicles is intended, mobilization had best be gradually effected in successive stages, and preferably without general anæsthesia, in order that the effect upon the hearing may be progressively tested.

In a case, for instance, of a large perforation of the drumhead with the tip of the malleus adherent to the promontory and adhesions or cicatricial bands obstructing the movements of other members of the ossicular chain, the first step should be the division of the adhesions at the tip of the malleus and gentle mobilization of that bone by means of a blunt hook. If it is decided to suspend interference at this point, the middle ear should be carefully dried and lightly packed with sterile, absorbent cotton, a dossil of cotton being placed behind the malleus to prevent recurrence of adhesion. At subsequent sittings, other bands and adhesions should be divided, circumcision of the stapes done, and tenotomy of either the tensor tympani or the stapedius muscles. It is occasionally possible, in cases of ankylosis of the ossicles, without fixation of the stapes, to utilize the ossicular chain as a columella by dividing the tendons of both the stapedius and tensor tympani muscles, and inserting an artificial drumhead.

If the chronic suppurative disease is in progress, and there are present the redundant granulomata which almost invariably indicate the existence of areas of necrotic bone, such surfaces should be carefully sought for and curetted either by means of the cup-shaped middle-ear or wire-ring curettes.*

* A convenient method of preparation and of carrying sterile absorbent cotton to be used for these and similar purposes in middle-ear operations is to roll the cotton into balls, place these on top of each other, in a small, tubular, screw-top glass bottle, bake from two to four hours at a temperature of 140° F., and open the bottle only when required for use.

* These curettes are made of stout steel wire drawn to a point, the point flattened into a disc, and the disc bored in the centre and filed at the edges to make a ring; the larger end of the wire is bent at an angle of forty-five degrees and made into a ring-shaped handle. They are simple in construction, easily made, and inexpensive.

The common seats of limited necrosis in the epitympanum are the head of the malleus, the body of the incus, and the outer epitympanic wall. The thorough cleansing of the epitympanum, which is necessary to the satisfactory treatment of all cases of suppurative epitympanic disease, and as an adjuvant to surgical interference, is best effected by means of the middle-ear syringe and the use of hydrogen dioxide; but as this remedy is, when used undiluted, distinctly irritating to the skin in some individuals, it is well previously to smear the canal walls lightly with vaseline. Limited curetting may be effectually done upon any portion of the tympanic wall or of the ossicles, but should be carefully restricted to the diseased area.

In the event of a considerable necrosis of the two larger ossicles, or when their presence presents an obstructive barrier to drainage from the epitympanum or to access to other diseased parts, their removal is indicated.

This operation should be done under general anæsthesia, not only because it is painful and may need to be considerably prolonged, but because a thorough examination and possibly curetting of the tympanic walls is a part of its purpose.

The instruments necessary, in addition to specula, blunt probes, cotton sticks, paracentesis needles, and a slender curved bistoury, are a spatula-shaped knife, for division of adhesions in the epitympanum, a wire snare or stout forceps for extraction of the malleus, an incus hook, or a blunt angular curette for removal of the incus, and a small blunt hook for use about the stapes; in addition, there should be a saturated solution of boric acid in alcohol and a solution of extract of suprarenal capsule, the former for dipping the instruments and the latter for controlling the sometimes annoying bleeding which obscures the field and prolongs the operation.

If the perforation is in the membrane of Shrapnell, the drumhead being intact, or if the perforation of the drumhead is small, the entire removal of that membrane accompanying the evulsion of the malleus may seem desirable, or the posterior portion of the drumhead may be retained to be carried inward and attached to the head of the stapes.

In this as in most other middle-ear operations under general anæsthesia, two assistants can be employed with advantage: one to etherize and to control the position of the head of the patient, the other to twist cotton sticks, cleanse and dry the instruments, and hand them to the surgeon when he wishes to keep his operative field continuously in view. Before using, and after each successive cleansing and drying, the blades of the instruments should be dipped in the alcoholic solution of boric acid, the speedy evaporation of the alcohol leaving the steel covered with a thin film of boric acid which dulls the metallic lustre and makes the instrument more plainly visible.

Partial or complete peripheral excision of the drumhead should be done with the parencentesis needle or curved bistoury, the membrane being, in addition, stripped from the handle of the malleus for the sake of removing an obstruction to both sight and manipulation and of making the malleus and the parts beyond it more accessible.

If the incus is in place and it is desired to remove it also, either subsequently to or simultaneously with the removal of the malleus, the next step would be the division of the incudo-stapedial articulation by means of the angular knife carried into the joint, from below upward, and cutting from behind forward against the pull of the stapedius muscle. The release of the incus from its attachment to the stapes allows the descending process to swing outward and downward into view and close to the long process of the malleus. If this movement fails to take place, it may be aided by means of the blunt hook, or, if desirable, the incus may be at once extracted. By passing the angular knife behind the tip of the long process of the malleus and carrying it upward in contact with the bone, the tensor-tympani tendon is felt and divided, the complete cutting of the tendon being usually made apparent by the increased mobility of the malleus. The division of the anterior and posterior ligaments of the short process, which steps follow next, leaves the malleus freed from its major attachments and makes it possible to determine how firmly it is held in place by other means, and, if it is resistant to a light pull with the forceps, the curved spatula knife should be passed upward into Prussak's space and swept backward and forward to divide the adhesions and thickened mucous membrane reduplications which fasten the heads of the larger ossicles to the outer epitympanic wall. To extract the hammer and anvil simultaneously, or to remove them individually, the loop of the wire snare should be drawn tightly about their descending processes as high up as possible, the movement of withdrawal being downward and slightly from side to side. If completely freed from attachment, they come away easily, and that these bonds should be thoroughly cut, especially above the short process of the malleus, is important because it is an evil experience, in removing that bone, to peel away the soft tissues from the superior wall of the inner end of the auditory canal. Throughout the operation, the extract of suprarenal capsule can be used with good effect, and after removal of the ossicles, the tympanum, and especially the epitympanum, should be swabbed with the alcoholic solution of boric acid and then dry-scrubbed by means of a cotton-tipped probe. The subsequent examination should include careful tactile survey of the tympanic and epitympanic walls and a determination of the condition of the stapes, necrotic spots should be curetted, adhesions in the fenestral niche divided, and if the stapes is otherwise free and can be utilized for sound transmission either by membranous attachment or the use of an artificial drumhead, the tendon of the stapedius muscle should be divided.

At the conclusion of the operation, the middle ear should be wiped dry, the canal washed with sterile water by means of a cotton-tipped probe, similarly scrubbed with alcohol, and then stopped with sterile cotton, this dressing to be renewed within forty-eight hours under aseptic precautions.

New cicatricial protective tissue forms rapidly from the cut edges of the drumhead in many of these cases, and especially, apparently, in those in which the middle ear has been rendered aseptic by operation and allowed to fill in with blood clot.

The obstructive changes which occur in the middle ear in non-suppurative diseases are so varied in location and extent as to make the question of the success of operation for relief of impairment of hearing a dubious one without better preliminary knowledge of the point in the sound-transmitting apparatus to be attacked and the extent of interference justifiable. Under these conditions of dubiety, it is very natural that recourse should be had to the somewhat desperate and frequently ineffectual major operation of removing the drumhead and two larger ossicles, but leaving the stapes, which was either or thus became the key to the unfortunate situation, untouched.*

This operation follows the same lines as the similar operation in suppurative cases; it is, however, comparatively bloodless, and the field remains clear; it demands, like the exploratory tympanotomy, the most stringent aseptic precautions.

Forcible mobilization of the ossicles by other than applications external to the middle ear may be effected by making a triangular cut in the posterior superior segment of the drumhead opposite the descending process of the incus and the stapes and the introduction of a small, blunt hook. The objections to this method of operating are the smallness of the field exposed and the consequent difficulty in manipulation: the location of the opening, in the centre of an important segment of the membrana vibrans, is of less importance, as it is well known that fresh incisions in the drumhead heal so readily that attempts to maintain a permanent opening by excising large portions, by the use of escharotics, and by introduction of eyelets have mainly failed of their purpose.

* Kessel's operation of removal of the drumhead, malleus, and incus, while exact as a surgical procedure, simple, easily done, and attended with but little risk, is unjustifiable unless warranted by a previous knowledge of what it is likely to effect in the individual case. In several cases of this kind which have come to my knowledge after the operation and when cicatricial healing had taken place, tenotomy hf the stapedius muscle alone, or with the use of an artificial drumoead, has given the sought-for improvement in hearing.

To permit free access to the middle ear in the line of the ossicular chain, to avail of the intelligent participation of the patient, and, if any operation more serious than an attempt at mobilization is found to be unjustifiable, to permit the immediate closure of the opening in the drumhead and the restoration of the parts to their former condition, the operation called exploratory tympanotomy was devised. This operation consists in an incision along and close to the posterior and superior periphery of the drumhead, beginning at a point opposite the round window, or a little higher, and ending close to the handle of the malleus below the short process; the dendritic fibrous tissue in the flaps thus formed tends to pull it downward and outward, thus exposing, without the need of manipulation, the descending process of the incus and the stapes, and permitting free, tactile access to the tensor-tympanic tendon and the tendon of the stapedius. The operation is done without general anæsthesia, thus making hearing tests during its progress possible, and is comparatively painless if the cut is made close to the periphery and if contact with the skin of the canal is avoided; in especially sensitive patients the incision may be suspended in its lower third and a sterile cocaine solution applied. Hemorrhage, even in the upper part of the cut, is usually inconsiderable, and can be easily controlled by sopping with a dry, cotton-tipped probe.

In a series of experiments on the progressive growth of the dermoid coat of the membrana tympani, it was found that the movement outward from the centre of the membrane at the tip of the malleus toward the superior and posterior periphery was slowest in the inferior third of the posterior segment, more rapid in the middle third, and most rapid in the upper third, and that the rate of movement, as shown by small pieces of paper pasted upon the membrane, bore a proportionate relation to the corresponding degree of vascularity of the three sections mentioned. Tactile examinations show that the sensitiveness of the sections of the posterior segment of the membrana tympani has the same relative correspondence, and therefore that an incision, begun opposite the round window, causes increasing pain, as it is extended upward and forward along the periphery.

A part of this progressive increase in pain can, of course, be accounted for psychologically; but it is evident that the edges of a small and comparatively painless cut can, by affording access to the mucous membrane forming the inner coat of the membrana tympani, be availed of for purposes of anæsthetization by cocaine, and that the cut can be successfully continued under the same influence and with comparatively little discomfort.

Tactile investigations as to the comparative sensitiveness of the different portions of the tympanic cavity also show its lining membrane and intrinsic structures, with exception of the superior and posterior portions—fornix tympani and aditus ad antrum mastoideum,—to be comparatively insensitive, especially in the line of the sound-transmitting apparatus of the middle ear.

Operations within the middle ear, therefore, except such as include interference with the membrana tympani and invasion of the upper portion of the tympanic cavity, may, in the great majority of non-suppurative cases, with proper care, be conducted not only without general, but also without local, anæsthesia; and in the cases, therefore, of chronic non-suppurative disease of the middle ear with intact membrana tympani, for which this operation of exploratory tympanotomy is proposed, when the sensitive membrana tympani has once been passed, there is opened to the observer an aseptic and comparatively insensitive cavity.

The successive stages of the exploratory tympanotomy are, first, the crescentic incision beginning in the posterior segment and carried upward and forward through the thin and comparatively insensitive portion of the drumhead between the annulus cartilagineus and the periphery, and then downward along the posterior border of the handle of the malleus. This cut may sometimes be completed without withdrawing the knife, but usually it is necessary to suspend it when the upper portion of the drumhead is reached, either for the purpose of making an application of cocaine or to allow the patient a moment of rest. Almost immediately upon the completion of the incision the flap thus formed curves downward and outward, leaving the descending process of the incus and sometimes the posterior crus of the stapes, the stapedius tendon, and the corresponding portion of the inner tympanic wall plainly in view. Bleeding from the cut edges is taken up by the cotton stick and the wound allowed to glaze. During this period of waiting the hearing tests are made and recorded.

Second, a small, blunt hook, previously dipped in the alcoholic boric-acid solution, is passed through the opening, care being taken to avoid touching the cut edges and inner surface of the flap, and the mobility of the malleus is tested by a series of gentle pulls, the same process being repeated by passing the hook behind the descending process of the incus and under the head of the stapes, the various degrees of fixation or mobility being determined by this means.

Third, from a piece of thin, foreign post paper, highly sized, there is cut, by means of curved scissors, a disc large enough to cover the flap formed in the drumhead and to extend upward over the periphery of the drumhead on to the inner end of the canal. This disc, dipped in a weak, corrosive solution to moisten its sizing, is then taken upon the end of a wet, cotton-tipped probe, and its lower half brought into contact with the outer surface of the flap in the drumhead and held in position for a few seconds until it adheres, when the paper, carrying the flap with it into position, may be similarly attached to the skin above the incision, thus bringing the edges of the crescentic cut in apposition and holding them firmly in place. The patient should be directed not to practise inflation, the ear should be lightly stopped with sterile cotton, and this dressing allowed to remain in place until the healing of the drumhead, which usually occurs within three days, has taken place.

In the second stage of this operation there may be included almost any form of interference in the line of the sound-transmitting apparatus of the middle ear, other than evulsion of the two larger ossicles. It is possible to disarticulate the incus and stapes, cut the tendon of the stapedius, and extract that bone and the incus also through such an opening as that described.

The operation of stapedectomy, while very simple in itself, is open to question because of the varied consequences which may follow invasion of the cavity of the internal ear, and because of its doubtful value for the purpose for which it is usually demanded—amelioration of an extreme degree of deafness.

When the extreme deafness is accompanied by disturbing or incapacitating tinnitus and vertigo, the removal of the stapes may be considered a justifiable expedient, and has occasionally proved of benefit. It should be borne in mind, however, that the fixation which causes these extreme symptoms is, not infrequently, only secondary to a hyperostotic process of the labyrinthine capsule which removal of the stapes cannot relieve, that, under these circumstances of fixation, the crura not unusually break in the attempt at extraction, and that there remains then only the alternative of drilling or of breaking up the base plate.

In 21 consecutive cases of attempted removal of the stapes in chronic, non-suppurative disease of the middle ear, the stapes was removed entire in 9 cases only; there was fracture of both arms of the stapes in 10 cases, and in 2 cases the bone was found to be so absolutely immovable as to make it impossible to rotate the head of the ossicle by traction upon the blunt hook in-