DISEASES OF THE

NOSE, THROAT AND EAR

FOR PRACTITIONERS AND STUDENTS

EDITED BY

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FOURTH EDITION, REVISED AND ENLARGED
WITH 243 ILLUSTRATIONS IN THE TEXT
AND 21 PLATES, OF WHICH 8 ARE IN COLOUR

PREFACE TO THE FOURTH EDITION

A FOURTH edition of this text-book, first published in 1924 along its present lines, has now become necessary.

Certain changes have been made in the authorship. Dr. A. Logan Turner and Dr. W. T. Gardiner, previously responsible for the section on the Diseases of the Nose and Paranasal Sinuses, no longer contribute to the volume, but the former continues to act as Editor. The section on Affections of the Paranasal Sinuses has been revised by Dr. G. Ewart Martin and Dr. Charles E. Scott, and Dr. Martin has recast the chapters on Peroral Endoscopy previously contributed by him. The Diseases of the Nose, Pharynx and Nasopharynx have been described by Dr. Douglas Guthrie in association with Dr. Charles E. Scott. Mr. J. D. Lithgow contributes the section on Diseases of the Larynx, as in previous editions, and Dr. J. S. Fraser, in coll boration with Dr. John P. Stewart. has again been responsible for hat on Diseases of the Ear.

Each section has been carefully rev ied and some new illustrations have been introduced. Nasal polypi have been described in a separate chapter and allergy and allied conditions have been similarly dealt with. The description of Sluder's intranasal operation on polypi and the operation of dacryocystostomy have been deleted. A short account has been given of certain vocal disabilities of singers.

A. LOGAN TURNER.

Edinburgh, February, 1936.

PREFACE TO THE FIRST EDITION

FOR a number of years, the small volume on Diseases of the Throat, Nose, and Ear, written by the late Dr. W. G. Porter, supplied a much-felt want, and the fact that it passed through three editions in a comparatively short space of time was sufficient testimony of its popularity.

Seven years have elapsed since Dr. Porter fell in the service of his Country, and, during the past twelve months, the third edition of his book has been out of print. The present volume, dedicated to his memory, is produced as the joint work of those engaged in the teaching and practice of the specialty in the Edinburgh Medical School.

While the writers have endeavoured to preserve the main object underlying Dr. Porter's original book, in providing the senior student of medicine and the practitioner with a single volume of moderate size, the subject matter has been expanded along new lines, which may be justly regarded as increasing the usefulness of the volume. For this purpose, an illustrated description of the clinical anatomy of the various regions has been introduced. This is an entirely new feature, and it is hoped that by this means the student will be able to obtain all the information which he may desire upon the applied anatomy of the different organs. It has been thought advisable to adopt the Basel nomenclature in the descriptive anatomy, at the same time introducing the old terminology for the benefit of those unacquainted with the new terms. A further addition will be found in the detailed account that has been given of many of the minor and major operations, some of which have been graphically illustrated. A section upon Endoscopy has also been added, as it seemed desirable that the practitioner should be acquainted with the modern developments in bronchoscopy

and œsophagoscopy, and should be cognisant of the indications for
their use.   No attempt has been made to instruct the reader in the
actual technique of this highly specialized branch of work.   In
some of the chapters the text shows little or no alteration from
that which appeared in Dr. Porter's third edition; other chapters,
again, have been entirely re-written and important new matter has
been added.   It is obvious, therefore, that the present volume has
been considerably enlarged and that many additional illustrations
have been introduced.

The chapter dealing with the Anatomy of the Nasal and Para-
nasal Cavities, and the section on the Diseases of the latter, have
been contributed by the Editor, while the chapters upon the
Diseases of the Nose have been written by Dr. W. T. Gardiner.
Dr. Douglas Guthrie has been responsible for the section on
the Pharynx and Nasopharynx, Mr. J. D. Lithgow for that
upon the Anatomy and Diseases of the Larynx, and Dr. G.
Ewart Martin for the section upon Endoscopy.   Dr. J. S. Fraser
has written the section on the Anatomy, Physiology, and Diseases
of the Ear.

The majority of the illustrations, a large number of which have
been well executed by Mr. James Grieve, have been prepared from
clinical cases, dissections, and microscopical preparations belonging
to the contributors of the different sections.   A few, however,
require special acknowledgement.   *Figs.* 1, 2, and 3, reproduced
from Cunningham's *Text-book of Anatomy*, have been kindly placed
at the disposal of the writers by Messrs. Hodder & Stoughton,
and *Figs.* 148 to 151 have been redrawn from illustrations appear-
ing in the same text-book.   *Fig.* 10 is copied from the English
translation of Spalteholz's *Anatomy*, published by J. B. Lippincott
Co.   *Figs.* 33 to 38, illustrating Sluder's operation upon the
ethmoidal and sphenoidal sinuses, have been redrawn by permission
of Mr. Henry Kimpton.   *Fig.* 61 has been redrawn from Escat's
work, and *Fig.* 63 from that of Chiari.   Permission has been granted
by Messrs. Baillière, Tindall & Cox for the reproduction of
Fig. 124, while *Figs.* 123 and 127 have been reproduced by the

kind permission of Dr. Chevalier Jackson. *Fig.* 136 is after Bezold ; *Figs.* 162, 178, 210 and 212 and *Plate XI* have been borrowed from the *Encyclopedia Medica*, William Green & Sons. *Figs.* 138 to 141 are copied from the class diagrams of Professor G. Alexander, of Vienna. *Fig.* 165 is from a diagram by Professor Ruttin, and *Fig.* 168 is modified from Jones and Fisher's volume on *Equilibrium and Vertigo*, published by J. B. Lippincott Co. The Editor regrets if any acknowledgment that should have been made has been inadvertently omitted.

The assistance of Dr. E. B. Jamieson, Department of Anatomy, University of Edinburgh, in revising the chapters on the Anatomy of the Ear is gratefully acknowledged ; to Mr. Alexander, Pharmacist to the Royal Infirmary, Edinburgh, the writers desire to express their indebtedness for his help in revising the formulæ in the Appendix.

<div style="text-align: right">A. LOGAN TURNER.</div>

Edinburgh, May, 1924.

<div style="text-align: center">The figure numbers given above are those in the 1927 edition.</div>

PLATES

DISEASES OF
THE NOSE, THROAT AND EAR

Section I.

DISEASES OF THE NOSE.

DOUGLAS GUTHRIE AND CHARLES E. SCOTT.

CHAPTER 1.

ANATOMY.

THE EXTERNAL NOSE, THE NASAL CAVITY, THE NASOPHARYNX AND THE PARANASAL SINUSES.

I. THE EXTERNAL NOSE (NASUS EXTERNUS).

SHAPED as a triangular pyramid, the external nose has its *root* above and its *base* directed downwards, the latter being perforated by two elliptical orifices, the *nares* or nostrils, separated from one another by a median septum. The free angle of the pyramid is the *apex* ; the anterior border joining the root and apex is the *dorsum*, while the upper part of the dorsum, supported by the nasal bones, is termed the *bridge*. Each side of the nose forms an open angle with the cheek and ends below in a rounded eminence, the *ala nasi*, the free edge of which forms the lateral boundary of the corresponding nostril. Over the apex of the nose, the skin is thick and adherent and contains many sebaceous glands.

The framework of the external nose is osseous and cartilaginous. The superior bony part is formed by the two *nasal bones* articulating medially, while laterally each is united with the frontal process of the maxilla. Superiorly, the nasal bone is attached to the frontal bone ; and inferiorly, the two bones, united to the lateral cartilages, constitute the upper boundary of the pyriform aperture which is completed laterally and below by the sharp anterior margins of the frontal processes and bodies of the two maxillæ.

Four paired and one unpaired cartilage take part in the completion of the external nose. The *lateral cartilages*, triangular in shape, lie immediately below the nasal bones and are attached to them and to the maxillæ by fibrous tissue. Medially, the antero-superior border of the cartilage of the septum is interposed between the lateral cartilages.

Their lower edges are joined by fibrous tissue to the upper margins of the greater alar cartilages (*Figs.* 1, 2, and 3).

The *greater alar cartilages* encircle the nostrils and assist in maintaining their patency. Each consists of a *medial* and *lateral crus*. The two medial crura together form the lowest part of the nasal septum and, being freely movable, constitute what is termed the *septum mobile nasi*. The lateral crura, oval in outline, are attached above and posteriorly to
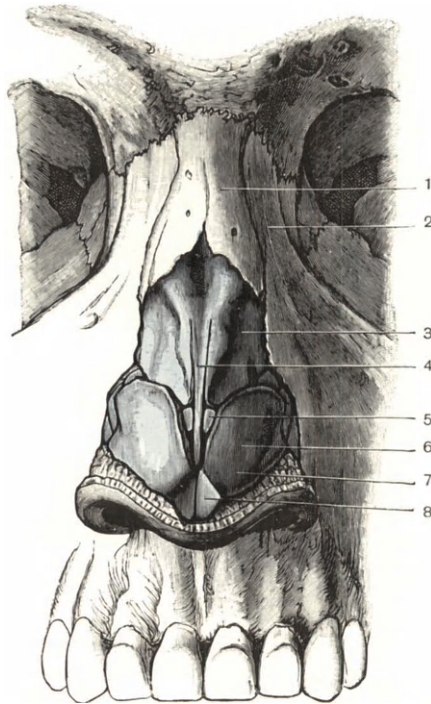

Fig. 1.—The external nose. (1) Nasal bone; (2) Frontal process of maxilla; (3) Lateral cartilage; (4) Cartilage of septum : (5) Accessory cartilage; (6) Greater alar cartilage; (7) Lateral crus; (8) Medial crus.

the lateral cartilages and to the maxillæ by fibrous tissue, in which two or three *lesser alar cartilages* are buried. The inferior edge of the lateral crus does not reach the free edge of the nostril, the lower part of the ala being devoid of cartilage and composed of subcutaneous fatty and connective tissue.

The *vomeronasal cartilages* constitute the last of the paired cartilages ; lying on either side of the postero-inferior edge of the cartilage of the septum they form narrow bands which are attached to the vomer.

The *cartilage of the septum*, as has been indicated, enters into the framework of the external nose. Its antero-superior border is fixed above to the posterior aspect of the internasal suture and, below this, it is directly continuous with the superior parts of the lateral cartilages,

which latter may be regarded as wing-like expansions of the septal cartilage. The antero-inferior border of the septal cartilage is short and is attached by fibrous tissue to the medial crura of the greater alar cartilages. Its anterior angle is rounded and does not reach the apex of the nose.

The chief *muscles* acting upon the external nose are the compressors and dilators of the nostrils and the depressors and elevators of the alæ
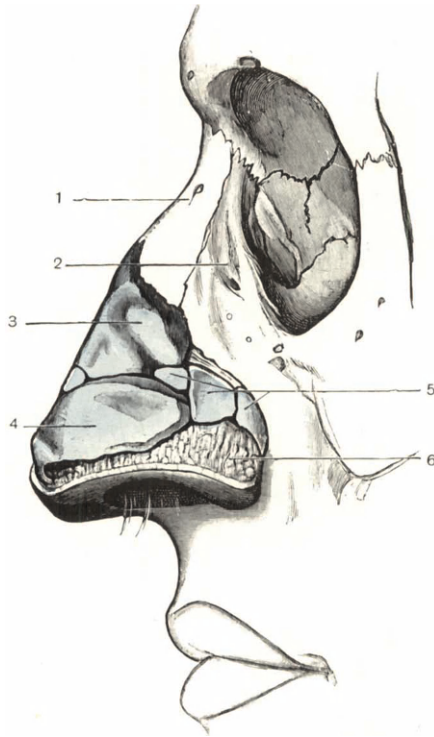

Fig. 2.—The external nose. (1) Nasal bone; (2) Frontal process of maxilla; (3) Lateral cartilage; (4) Greater alar cartilage; (5) Lesser alar cartilages; (6) Fatty tissue of ala nasi.

nasi. They are supplied by the facial nerve. In mouth-breathers the dilators and elevators tend to atrophy from disuse, so that the anterior nares become narrow and slit-like.

The external nose receives its *blood-supply* from the external maxillary (facial) and ophthalmic arteries, while the veins communicate with the anterior facial and ophthalmic veins, the latter being tributaries of the cavernous blood sinus. The main *lymphatic* vessel follows the course of the anterior facial vein. It receives lymphatics from the anterior part of the nasal mucous membrane and ala nasi, and opens into the sub-maxillary lymph-glands, but other lymph-vessels from the external nose

course laterally and communicate with the anterior auricular lymph-glands.

Through the intercommunication between the mucosal and cutaneous lymphatic network, lupus of the anterior part of the nasal mucous membrane may spread to the alæ nasi and the skin covering the face.
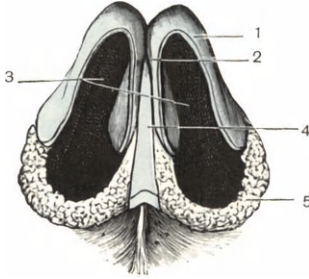

Fig. 3.—The external nose. (1) Lateral crus of greater alar cartilage; (2) Medial crus of greater alar cartilage; (3) Nares; (4) Lower edge of cartilage of septum; (5) Fatty tissue of ala nasi.

II. THE NASAL CAVITY (CAVUM NASI).

The Lateral Wall of the Nasal Cavity.—The lateral wall of the nasal chamber presents an irregular appearance due to the convoluted arrangement of the three nasal conchæ. The superior and middle conchæ constitute the medial surface of the lateral mass of the ethmoid bone, the *conchæ ethmoidales*, of which they form an integral part (*ethmo-turbinated bones*).

The middle concha, which forms an attachment anteriorly with the ethmoidal crest or agger nasi on the medial aspect of the frontal process of the maxilla, projects downwards from the lateral ethmoid mass and thus overhangs and conceals the superior part of the middle meatus. The inferior nasal concha is a separate bone, articulating mainly with the maxilla (*maxillo-turbinated bone*) (*Fig.* 4).

Each nasal concha overhangs a channel or meatus corresponding in length to the concha beneath which it is situated. Thus, the *superior meatus*, with a general direction backwards and downwards, is confined to the posterior third of the lateral wall, its anterior end terminating in a cul-de-sac. *The middle meatus*, commencing at the posterior naris, is directed forwards for about two-thirds of the length of the lateral wall, communicating anteriorly with the *atrium meatus nasi*, a slightly depressed area immediately above the nasal vestibule. One or more accessory ostia of the maxillary sinus may be seen occasionally in the posterior part of the middle meatus (*Fig.* 4).

The inferior meatus, corresponding to the floor of the nasal cavity, extends from the anterior to the posterior naris. A fourth and very small meatus may lie above and parallel to the superior meatus as a groove in the lateral wall of the *spheno-ethmoidal recess*. This recess is a shallow but well-defined hollow between the posterior end of the superior concha and the anterior aspect of the body of the sphenoid bone. The space or cleft intervening between the medial surfaces of the conchæ and the septum of the nose, and extending from the roof to the floor of the nasal cavity, is named *the common meatus*. The portion of it which intervenes between the ethmoidal conchæ and the septum is termed *the olfactory sulcus* (*see Fig.* 15).

The superior and middle meatuses derive clinical importance from the fact that the paranasal sinuses communicate with them by means of

small ostia. The position of these openings is well seen in *Figs.* 4 and 5. The inferior meatus receives at its anterior end the opening of *the naso-lacrimal canal*, situated under cover of the inferior concha and close to the attachment of that bone to the lateral nasal wall.

As the middle meatus requires closer inspection, the attachment of the middle nasal concha must be divided throughout its entire length and the overhanging portion removed, so as to bring into view the whole surface area of the meatus. This has been done in *Fig.* 5. Two prominent structures are thus seen ; the convex surface of the bulla
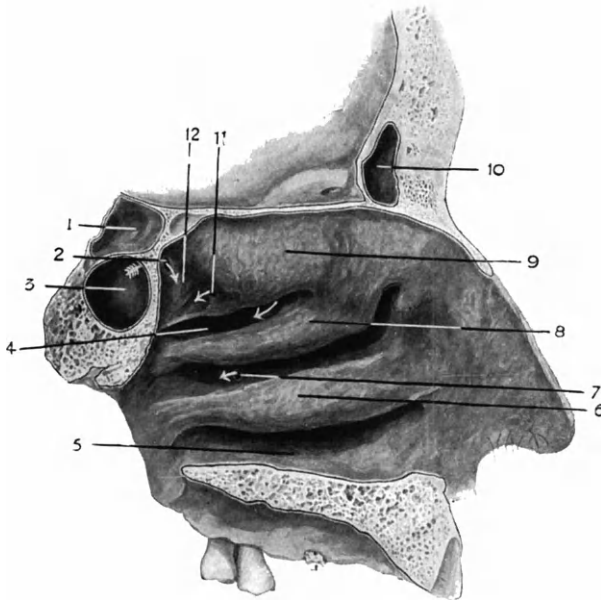
Fig. 4.—Lateral wall of left nasal cavity, showing the conchæ or turbinated bodies, the meatuses, and spheno-ethmoidal recess. (1) Right sphenoidal sinus ; (2) Sphenoidal ostium ; (3) Left sphenoidal sinus ; (4) Superior meatus ; (5) Inferior meatus ; (6) Inferior concha ; (7) Accessory ostium of maxillary sinus ; (8) Middle concha ; (9) Superior concha ; (10) Frontal sinus ; (11) Ostium of posterior ethmoidal cells ; (12) Spheno-ethmoidal recess.

cell of the ethmoid labyrinth (*bulla ethmoidalis*) and, anterior and inferior to it, the well-defined curved free margin of the uncinate process of the ethmoid (*processus uncinatus*). Between these two structures there is a narrow interval, the *semilunar gap* (hiatus semilunaris) which serves as a communication between the middle meatus and a small triangular shaped channel or gutter, the *semilunar groove* (infundibulum ethmoidale), bounded superiorly by the inferior surface of the bulla, and inferiorly and medially by the lateral surface of the uncinate process. Posteriorly and inferiorly, the semilunar groove is closed by a bony lamina connecting the posterior end of the bulla with the uncinate process. *The ostium maxillare* communicates with the most inferior part of the infundibulum. Superiorly and anteriorly the infundibulum may terminate

in one of two ways.   In about one-half of the heads examined a bony lamina connects the anterior end of the uncinate process with the bulla ; here the semilunar groove receives the ostium of an anterior ethmoidal cell.   In these cases the frontal sinus opens directly into the middle meatus anterior to the semilunar groove (*Fig.* 5).   In the remainder of the heads this channel is continued upwards to the ostium frontale as *the naso-frontal duct* (*Fig.* 6).   This duct varies somewhat in its direction
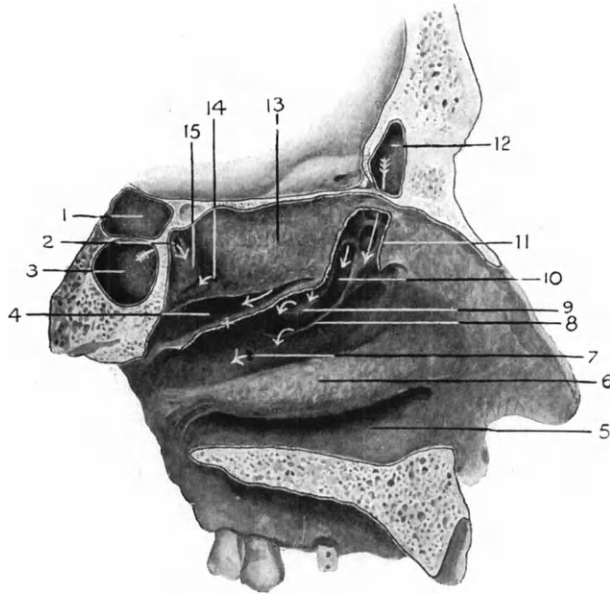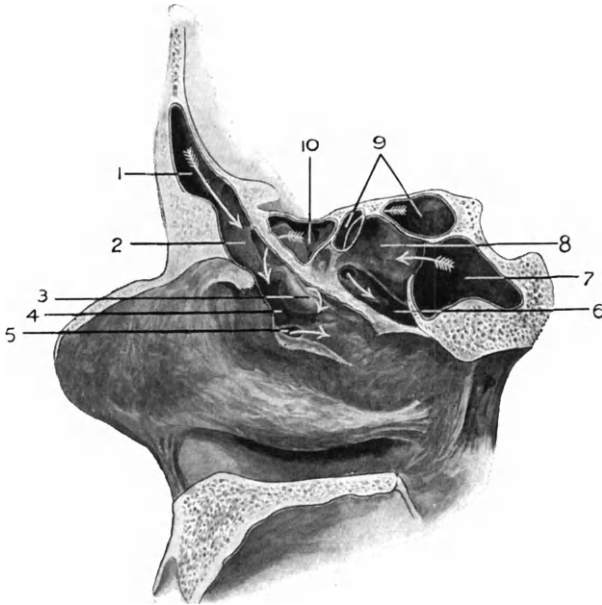

Fig. 5.—Lateral wall of left nasal cavity with the middle concha removed along the line indicated by + ; the lateral wall of the middle meatus is exposed, and the position of the ostia of the sinuses is indicated by arrows.   (1) Right sphenoidal sinus ;   (2) Sphenoidal ostium ; (3) Left sphenoidal sinus ;   (4) Superior meatus ;   (5) Inferior meatus ;   (6) Inferior concha ; (7) Accessory ostium of maxillary sinus;   (8) Uncinate process ;   (9) Ethmoidal bulla ;   (10) Infundibulum or semilunar groove;   (11) Naso-frontal duct ;   (12) Left frontal sinus; (13) Superior concha;   (14) Ostium of posterior ethmoidal cells ;   (15) Spheno-ethmoidal recess.

and in the calibre of its lumen, consequent upon the irregular develop-ment of the ethmoidal cells surrounding it, and, for this reason, access to the frontal sinus by probe or catheter passed from the nasal cavity may become somewhat difficult.

The Septum Nasi, or medial wall of the nasal cavity, is in part osseous and in part cartilaginous.   (*Figs.* 7, 8.)   It is formed mainly by the per-pendicular plate of the ethmoid superiorly and posteriorly and by the vomer inferiorly and posteriorly, while the septal cartilage, anteriorly, fills in the angular interval between these two bones.   The following additional bony processes complete its structure ; the frontal spine and the crest of the nasal bones anteriorly and superiorly, the rostrum of the sphenoid posteriorly and, in the median plane inferiorly, the nasal crests of the maxillæ and palatine bones.   The cartilage of the septum

is strengthened anteriorly by the medial part of the greater alar cartilages, and along its inferior margin by the vomeronasal cartilages. The main arterial supply to the septum nasi is derived from the septal branch of the sphenopalatine artery which courses along the surface of the vomer ; it anastomoses at the anterior inferior part of the septum with the great palatine artery (superior palatine) and with the septal branch of the superior labial (coronary) artery (*Fig.* 8). The site of anastomosis constitutes the 'bleeding area' of the septum.

Fig. 6.—Lateral wall of right nasal cavity with the superior and middle conchæ removed ; the infundibulum and naso-frontal duct are continuous ; the uncinate process has been turned down in order to show the maxillary sinus ostium. (1) Right frontal sinus ; (2) Naso-frontal duct ; (3) Ethmoidal bulla ; (4) Infundibulum or semilunar groove ; (5) Maxillary ostium ; (6) Superior meatus ; (7) Right sphenoidal sinus ; (8) Spheno-ethmoidal recess ; (9) Posterior ethmoidal cells ; (10) Anterior ethmoidal cell.

The Roof of the nasal cavity is very narrow save in its posterior part ; anteriorly, it is formed by the nasal and frontal bones ; in its middle portion by the cribriform plate of the ethmoid bone, which is perforated by the foramina transmitting the branches of the olfactory nerve, the nasal nerve and the ethmoidal vessels ; and posteriorly, by the body of the sphenoid bone.

The Floor of the nasal cavity, which is shorter and wider than the roof, is nearly horizontal from before backwards, but is slightly concave transversely. Its transverse diameter measures 1 cm.

The *mucous membrane* of the inferior concha consists of a layer of fairly dense connective tissue containing the larger blood-vessels and some unstriped muscle fibres ; in addition, it contains an erectile tissue layer made up of thin-walled blood-vessels of irregular size and shape : this is better developed at the anterior and posterior ends of the concha

and along its inferior border than elsewhere. Along the periosteal aspect of the mucous membrane, and also beneath the epithelial basement membrane, is a layer of elastic fibres with similar fibres running radially between them. The whole constitutes an elastic tissue framework which causes the mucosa to return to its normal size when the vascular engorgement of the erectile tissue has passed off. The surface epithelium is of the columnar ciliated type and beneath it are several layers of cubical cells resting upon the basement membrane. The racemose mucous glands lie beneath the latter, their ducts passing through it and opening upon the surface. (*See Figs*. 24 and 35, pp. 26 and 39.)
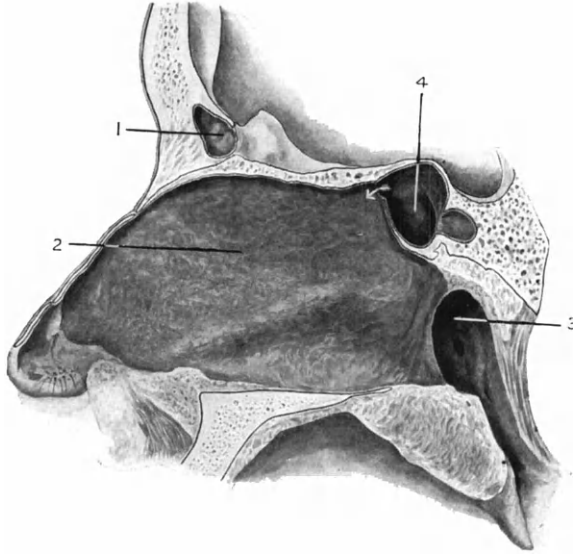

Fig. 7.—Left side of the nasal septum, covered with mucous membrane, showing an oblique septal crest at the junction of the vomer with the cartilage of the septum. (1) Left frontal sinus; (2) Septum of the nose; (3) Nasopharyngeal cavity; (4) Left sphenoidal sinus.

The mucous membrane of the middle concha, while resembling generally that of the inferior, differs in the fact that it does not contain the same amount of erectile tissue, while in general structure it is looser and more delicate.

The *sensory nerve-supply* (*Figs*. 8, 9) of the nasal mucous membrane is furnished mainly by the maxillary division of the trigeminus through the branches arising from the sphenopalatine ganglion (Meckel), which is situated in the superior part of the pterygopalatine fossa in close proximity to the sphenopalatine foramen. " The foramen lies at a point just posterior to and immediately above the posterior tip of the middle concha " (Sluder). The ganglion may be found as close as 1 or 2 mm. to the nasal mucosa, or separated from it at a distance of 9 mm. The anterior portion of the lateral wall and of the nasal septum receives its supply from the ophthalmic nerve through its lateral and medial nasal branches. The infra-orbital nerve or terminal branch of the maxillary

nerve through its anterior dental branch supplies the anterior end of the inferior concha and adjacent nasal floor.

Secretory nerve fibres supplying the various glandular structures and the involuntary muscle tissue belong to the autonomic nervous system. The autonomic nervous system consists of two parts which are anatomically and physiologically distinct—namely (1) the sympathetic and (2) the parasympathetic. T h e parasympathetic fibres arise in part from the brain ştem and in part from the sacral region of the cord, the sympathetic fibres taking origin from the spinal cord alone. The former set of fibres is contained in the third,
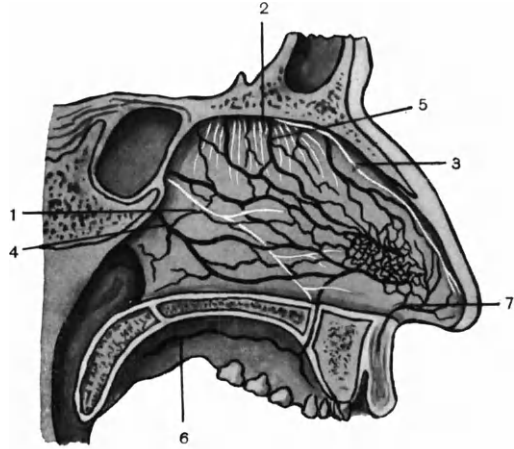

Fig. 8.—Right side of the nasal septum, showing the nervous and arterial supply, and the 'bleeding area' of the septum anteriorly and inferiorly. (1) Right nasopalatine nerve; (2) Olfactory nerve branches; (3) Medial nasal nerve; (4) Septal posterior nasal artery from spheno-palatine; (5) Anterior and posterior ethmoidal arteries; (6) Great palatine artery; (7) Septal branch of superior labial artery.

seventh, ninth, tenth and eleventh cranial nerves, and innervate the blood-vessels of the mucous membrane of the mouth, throat, nose, paranasal sinuses, the salivary glands and the glands and musculature of the trachea and bronchi. The parasympathetic fibres, which control vasodilatation and secretion within the nose, are contained in the trunks of the seventh and ninth nerves and are distributed by way of the sphenopalatine ganglion (*Fig.* 9). The sympathetic fibres have a directly opposite action. They control vasoconstriction, but their dis-
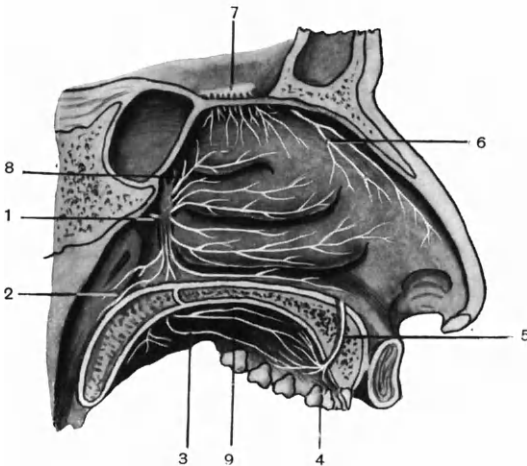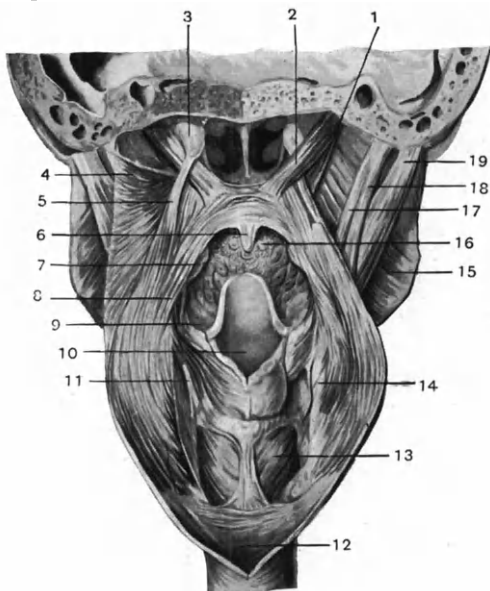

Fig. 9.—Innervation of the lateral nasal wall. (1) Sphenopalatine ganglion (Meckel); (2) Posterior palatine nerve; (3) Middle palatine nerve; (4, 5) Nasopalatine nerve; (6) Lateral nasal nerve; (7) Olfactory tract and branches; (8) Posterior-superior lateral nasal nerve; (9) Anterior palatine nerve.

tribution and mode of action are not yet fully elucidated.

The *olfactory nerves*, some twenty filaments in number, derived from the olfactory bulb lying upon the cribriform plate, enter the nasal cavity through foramina piercing the osseous plate ; they are distributed in a network lying in the mucous membrane covering the upper third of the nasal septum, nearly the whole of the opposed medial surface of the superior concha and a small part of the medial surface of the middle concha anteriorly (*Figs.* 8, 9).

The perineural sheaths of the olfactory nerve filaments—erroneously described as lymph sheaths—communicate directly with the pia-arachnoid spaces. This communication has been demonstrated experimentally in animals and young human subjects by injecting the spaces with coloured material which passed downwards through the cribriform foramina transmitting the olfactory nerves. Conversely, infection of the perineural sheaths from a primary septic focus within the nose has been demonstrated microscopically in patients dying of acute purulent leptomeningitis, following intranasal operations during which the sheaths have been torn. The pus traced upwards within the sheaths has been found directly continuous with the pus in the soft membranes.

Fig. 10.—Dissection of pharynx. (1) Tensor palati ; (2) Levator palati ; (3) Cartilage of Eustachian tube; (4) Superior constrictor ; (5) Salpingopharyngeus ; (6) Uvula ; (7) Palatine tonsil ; (8) Palatopharyngeus ; (9) Pharyngo-epiglottic fold ; (10) Upper aperture of larynx ; (11) Superior laryngeal nerve ; (12) Œsophagus ; (13) Crico-arytenoideus posticus ; (14) Posterior border of thyreoid cartilage ; (15) Internal pterygoid ; (16) Tongue ; (17) Stylopharyngeus ; (18) Stylohyoid ; (19) Digastric.

The olfactory area of the nasal cavity is, therefore, a potential danger zone. This fact should be borne in mind when operating on the ethmoidal cell labyrinth. (*See Fig.* 41, p. 47.)

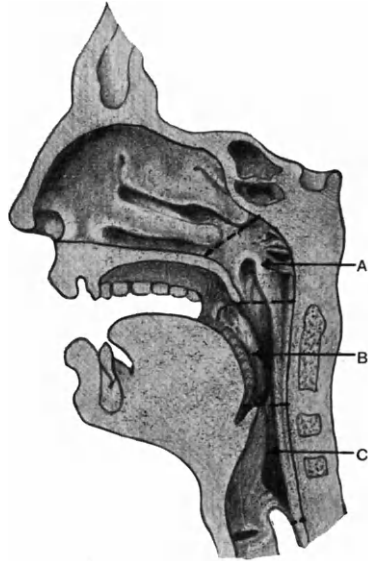The *veins* from the walls of the nasal cavity pass for the most part through the sphenopalatine foramen and terminate in the pterygoid plexus, but branches join the superior ophthalmic vein in the orbit, and anteriorly there is intercommunication with the anterior facial vein.

The *lymphatic vessels* of the most anterior part of the nasal mucosa pass forwards and, joining the cutaneous lymphatics of the nasal vestibule, accompany the anterior facial vein and enter the submaxillary glands ; the efferents of these glands drain into the superior deep cervical glands. The lymphatics from the rest of the nasal mucous membrane pass backwards and, finally, enter the medial superior deep cervical glands, some of them in their course passing through the retropharyngeal glands.

The main functions of the nasal cavities are olfactory, respiratory and vocal. With the sense of smell there is intimately bound up the power of appreciating flavours, a sensation which is popularly ascribed to taste. Through nasal respiration the air is warmed, moistened and filtered. Upon the patency or otherwise of the nasal and post-nasal cavities the resonance of the voice is largely dependent.

III. THE NASOPHARYNX (PARS NASALIS).

The nasopharynx (pars nasalis, *Figs.* 10, 11), with the exception of the floor, which is formed by the soft palate, has rigid and immovable boundaries. The roof, formed by the body of the sphenoid bone and basi-occipital, curves downwards and backwards so as to become continuous with the posterior wall; the latter is almost vertical and is formed by the upper cervical vertebræ, clothed by the prevertebral muscles and the mucosa, which is lined for the most part by columnar ciliated epithelium. On the roof and posterior wall in young children lies an aggregation of lymphoid tissue known as the pharyngeal tonsil; 'adenoids', so common in childhood, is the name applied to enlargement of this structure (*see Fig.* 77). Anteriorly the nasopharynx communicates with the nasal cavities through the posterior nares or choanæ, which are separated from each other by the septum nasi. The lateral wall of the nasopharynx is of importance, as here is situated on either side the orifice of the auditory tube (Eustachian tube). The opening, which is directed downwards, forwards and medially, pre-

Fig. 11.—Anatomical divisions of the pharynx. **(A)** Nasal pharynx (pars nasalis); **(B)** Oral pharynx (pars oralis); **(C)** Laryngeal pharynx (pars laryngea).

sents a funnel-shaped appearance and is bounded superiorly and posteriorly by the salient rounded ridge of the torus tubarius (Eustachian cushion) formed by the projection of the cartilage which partially surrounds the Eustachian tube. The ostium tubæ (Eustachian orifice) is situated just superior to the plane of the hard palate. The mucosa lining the tube is directly continuous with that of the nasopharynx, and is likewise covered by ciliated epithelium. It is well supplied with mucous glands, and in the submucous layer there is, in early life, an aggregation of lymphoid tissue. Immediately posterior to the Eustachian cushion is a deep depression known as the recessus pharyngeus (fossa of Rosenmüller). (*See also* Chapter XIV.)

IV. THE PARANASAL SINUSES (SINUS PARANASALES).

The paranasal air sinuses, arranged in pairs, are situated in relation to each nasal cavity. They may be appropriately studied, both on anatomical and clinical grounds, as comprising two groups, the anterior and the posterior. The former includes the maxillary sinus (antrum Highmori), the anterior ethmoidal cells, and the frontal sinus, cavities communicating with the middle meatus of the nose under cover of the concha nasalis media (the middle turbinal). The posterior group contains the posterior ethmoidal cells and the sphenoidal sinus, communicating with the superior meatus and with the small spheno-ethmoidal recess on the lateral nasal wall immediately above the meatus.
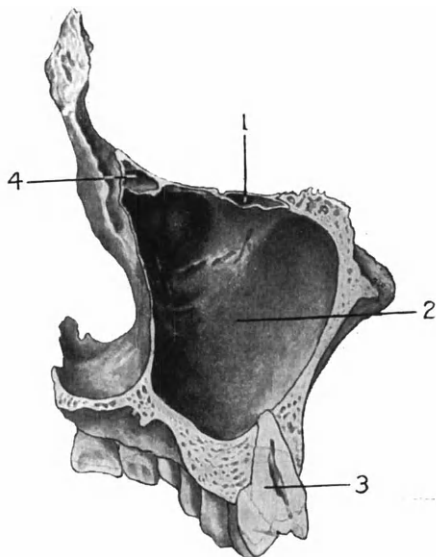

Fig. 12.—Coronal section of the right maxilla during the period of the first dentition ; the small maxillary sinus lies medially to the infra-orbital canal : the maxilla consists largely of cancellous bone. (1) Infra-orbital canal ; (2) Right maxillary sinus ; (3) Second molar tooth.

The position of the various openings or ostia are represented in *Figs.* 4 and 5, and a study of the dissection renders a detailed description unnecessary.

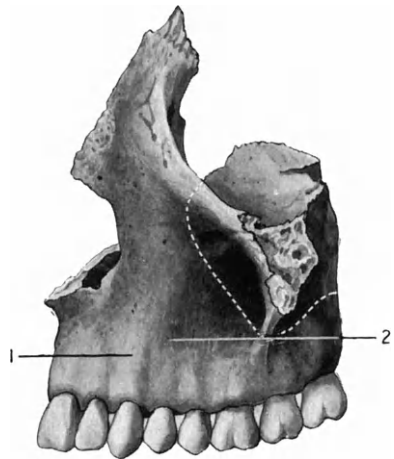The sinuses are lined by mucous membrane continuous through the ostia with that covering the nasal cavity. The lining epithelium consists of ciliated cylindrical cells. A few mucous glands are found scattered in the deeper connective tissue ; an aggregation of these glands is met with in the neighbourhood of the ostium of the sinus. The sinuses probably assist in developing the resonance of the voice.

The Maxillary Sinus (Antrum Highmori).—This cavity is present at birth as an outgrowth from the middle meatus. Associated with the enlargement of the maxillary bone by the deposition of cancellous osseous tissue between its palatal and orbital surfaces, there is a slowly progressive absorption of the same on the medial nasal aspect of the maxilla. In this way the sinus gradually increases in size, extending outwards into the body of the upper jaw. and reaching its maximum dimensions about the 25th year, after

Fig. 13.—Coronal section of the right maxilla of an adult, showing the fully developed maxillary sinus. The floor of the sinus is on a lower plane than that of the nasal floor ; the molar fang projects into the cavity of the sinus. (1) Infra-orbital canal; (2) Right maxillary sinus ; (3) First molar tooth : (4) Maxillo-ethmoidal cell.

the eruption of the last permanent molar tooth (*Figs.* 12, 13). In the first year of life the body of the maxilla is occupied mainly by the dental sac, the sinus being confined to a relatively small area lateral to the middle meatus. Between the final eruption of the temporary teeth at the end of the 2nd year and the commencement of the appearance of the permanent teeth in the 7th year, the cavity assumes considerable dimensions, so that in a child of $7\frac{1}{2}$ years it may measure $\frac{3}{4}$ in. in its transverse diameter, 1 in. vertically, and $1\frac{1}{2}$ in. in its antero-posterior depth. The antrum may thus very early attain surgical importance, and pus has been evacuated from it in the third and fourth years.

The sinus is somewhat pyramidal in shape; its *roof*, in the adult, is formed by the floor of the orbit, which is traversed from behind forwards by the infra-orbital canal transmitting the nervus maxillaris (maxillary nerve) and its accompanying vessels. The *floor* is the alveolar or dentary border of the maxilla and therefore bears an important relation to the teeth and their sockets. After eruption of the permanent teeth, it occupies a lower level than the plane of the nasal floor and, in a well-developed sinus, the floor extends from a point above the root of the first premolar backwards over the roots of the third molar. Variations in the size of the sinus alter these dental relationships. The thickness and the density of the bone between the teeth roots and the sinus cavity vary, dehiscences or gaps sometimes being found in it. Dental infection of the sinus is probably of less frequent occurrence than nasal infection (according to C. J. Lewis and Logan Turner, in only one-third of the cases). Transverse ridges of bone may be found

Fig. 14.—Left maxilla showing a marked concavity of the facial wall with consequent encroachment upon the cavity of the sinus. The dotted line indicates the nasofacial angle of the maxillary sinus. (1) Canine ridge; (2) Canine fossa.

in the floor of the sinus, thus producing alveolar pockets of varying depth.

The *posterior wall* is a thin plate of bone separating the cavity from the infratemporal and pterygopalatine fossæ (zygomatic fossa). The *antero-lateral* or *facial wall* is limited laterally by the zygomatic process and medially by the canine ridge which, in a sinus of average dimensions, is the surface indication of the junction of the nasal and facial walls of the cavity. The interval between the canine and zygomatic processes is the canine fossa, in the upper part of which is the infra-orbital foramen.

When the sinus is opened through the facial wall, the canine and zygomatic ridges should be defined : if the facial wall is markedly concave, then the canine ridge does not define the nasofacial angle of the sinus, but lies anterior to it, the cavity of the sinus being reduced in size (*Fig.* 14). In these circumstances the surgeon should open the

cavity nearer the zygomatic process and carefully enlarge the opening forwards in the medial direction ; thus it is possible to avoid opening directly into the nasal cavity.

The *medial* or *nasal wall*, the base of the pyramid, is subdivided into an upper and lower segment, demarcated from each other by the plane of attachment of the inferior concha. The lower segment, osseous throughout, forms the lateral wall of the inferior nasal meatus. The bone is thinnest immediately below the attachment of the concha, and in that situation offers least resistance to the passage of the trocar when the sinus is explored through the anterior naris. The upper segment of the nasal wall is the lateral boundary of the middle meatus, osseous anteriorly but membranous in its posterior half. The opening of the sinus (*ostium maxillare*) is situated in the middle meatus and lies immediately beneath the roof of the antrum, unfavourably placed for drainage of the cavity in the erect posture (*Fig.* 15). When viewed from the nasal aspect the ostium is seen in the lowest part of the semilunar groove (*see Fig.* 6). One or more accessory ostia are sometimes found in the membranous part of the meatal wall ; they are placed posterior to and on a plane inferior to the normal ostium, thus favouring drainage in a backward direction when the cavity is infected (*see Fig.* 4).

Fig. 15.—Coronal section through the nasal cavities and maxillary sinuses on the plane of the ostia of the sinuses (viewed from behind). (1) Left frontal sinus; (2) Left anterior ethmoidal cell ; (3) Olfactory sulcus ; (4) Right anterior ethmoidal cells ; (5) Right frontal sinus ; (6) Ethmoidal bulla ; (7) Hiatus semilunaris ; (8) Infundibulum or semilunar groove ; (9) Uncinate process ; (10) Middle conchal cell ; (11) Middle meatus ; (12) Inferior concha ; (13) Maxillary sinus ; (14) Inferior meatus.

Variations in the size of the sinus are met with, which may lead to considerable asymmetry if unilateral. Diminution in size may be caused by insufficient absorption of the cancellous structure of the maxilla, so that the walls of the sinus are thicker than normal ; or it may be the result of undue approximation of the facial and nasal walls. These variations interfere with the diagnostic illumination tests and will influence operative procedures on the sinus. On the other hand, the cavity may exceed the average dimensions and show a pronounced development of the alveolar recess and an extension into the hard palate beneath the floor of the nose.

Osseous ridges and incomplete bony partitions occasionally cross transversely the floor of the sinus ; but complete subdivision into an anterior and posterior cavity, producing true anatomical duplication of the sinus, is very rare. When present, it is the result of two developmental outgrowths from the middle meatus, both cavities communicating with that channel. Apparent duplication is sometimes met with, where a horizontal bony partition subdivides the sinus, usually in its posterior part, into an upper and lower cavity. In these cases the ostium of the former communicates with the superior meatus, the air space being a large posterior maxillo-ethmoidal cell, while the lower cavity is the true antrum and communicates with the middle meatus.

The Frontal Sinus (Sinus Frontalis).—The frontal sinus develops soon after birth as an upward prolongation of the frontal recess situated in the middle meatus. As the result of the absorption of the cancellous tissue between the two tables of the frontal bone, the cavity extends for a varying distance into its frontal and orbital plates and occupies an area above the root of the nose and the supra-orbital margin. The development of the cavity in the early years of life is subject to considerable variation, but a well-formed sinus has been recognized and opened for the relief of suppuration between the third and fourth years.

The sinus is somewhat pyramidal in shape and presents, usually, a vertical or frontal portion and a horizontal or orbital part. It has three walls, and a septum or partition which intervenes between the two sinuses. The *anterior wall*, formed by the convex outer table of the frontal bone, varies in thickness and frequently contains marrow spaces ; the *posterior* or *cerebral wall*, in part vertical and in part horizontal, is thinner and consists mainly of compact bone ; the *inferior wall* or *floor*—the thinnest of the three—lies in the horizontal plane and forms part of the orbital roof. Medially, the sinus overlies the anterior ethmoidal cells, and laterally, the cavity of the orbit, the extent of this area varying with the development of the horizontal portion of the sinus. The *septum*, as a rule a thin bony partition, intervenes between the two sinuses. It may occupy the median plane throughout its whole length, but it is subject to considerable deviation to the right or left, thus producing in some cases marked asymmetry of the two cavities.

The *ostium frontale* is situated in the floor of the sinus in relation to the medial or ethmoidal portion and is thus advantageously placed for the drainage of inflammatory products.

One or both frontal sinuses may be absent (in 17 per cent of European crania—Logan Turner).

The sinus, both in its vertical and horizontal parts, varies in size in different individuals. It may be a shallow cavity confined to a small area above the root of the nose, or it may extend laterally into the base of the zygomatic process of the frontal bone (external angular process) ; and vertically it may reach the frontal tuberosity or eminence. Similarly, the horizontal portion is subject to great variation, being limited in one case to the medial third of the orbital roof, in another extending posteriorly as far as the apex of the orbit and laterally to the zygomatic

process.   An air-cell in the crista galli of the ethmoid bone has been found to communicate with the frontal sinus (Ladislaus Onodi).   Thus, the relations of the sinus to the frontal lobes of the brain and to the contents of the orbit show considerable variation.   The sinus may be irregularly subdivided by incomplete bony partitions, and contain recesses and diverticula which may become pockets of infection when the cavity is the seat of suppuration.   Variations in the frontal sinus may be studied on *Plate 1*.

The Ethmoidal Cell Labyrinth (Cellulæ Ethmoidales).—The ethmoidal air-cells, some of which are present at birth, arise as prolongations of

the nasal mucosa into the lateral mass of the ethmoid bone.   In adult life they vary in number, size and shape. For clinical purposes they may be grouped as anterior and poster-ior cells, communicating respectively with the middle and superior meatuses (*see Figs.* 5, 6). The ethmoid labyrinth is placed antero-poster-iorly along the entire superior half of the nasal cavity, with the latter lying medially. and the orbit on its lateral aspect.

Six walls can be dif-ferentiated.   The *super-ior* or *cerebral wall* is completed by the depressions or foveæ on the ethmoidal edge of the orbital plate of the frontal bone, and the *inferior wall* by the
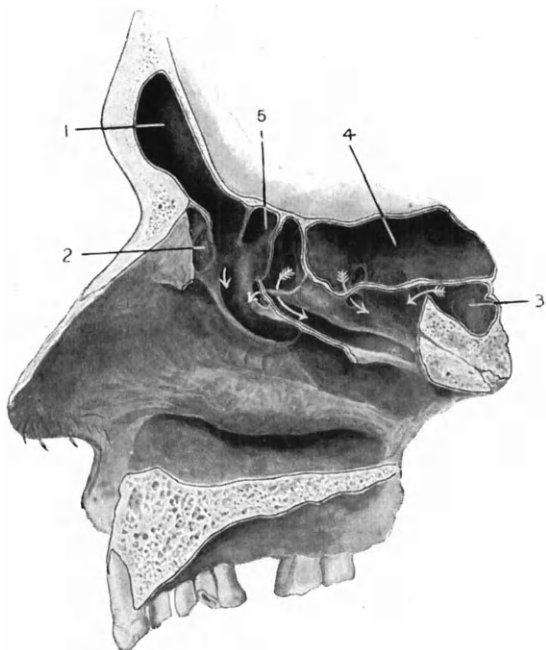
Fig. 16.—Lateral wall of right nasal cavity.   (1) Frontal sinus ;
(2) Cell of the agger nasi ;   (3) Sphenoidal sinus :   (4) Large
spheno-ethmoidal cell ;   (5) Anterior ethmoidal cell.

medial margin of the orbital plate of the maxilla anteriorly and by the orbital process of the palatine bone posteriorly.   The *lateral* or *orbital wall* is formed mainly by the lamina papyracea of the ethmoid, com-pleted anteriorly by union with the lacrimal bone and posteriorly with the sphenoid bone, while the *medial* or *nasal wall* is formed by the convoluted ethmoidal conchæ (superior and middle turbinated bones).   *Anteriorly* the labyrinth is completed by the frontal process of the maxilla, and *posteriorly* by articulating with the sphenoidal spongy bone.   The air-spaces in each group intercommunicate, but the anterior cells are closed off from those of the posterior group.   It is not uncommon to find

PLATE I

VARIATIONS IN THE CONFIGURATION OF THE FRONTAL SINUS

(1) Frontal sinuses of average dimensions. (2) Left frontal sinus with recess at lateral angle. (3) Narrow right frontal sinus and very oblique intersinus septum. (4) Two small, almost symmetrical, frontal sinuses. (5) Left frontal sinus incompletely subdivided by a vertical partition. (6) Large right frontal sinus beneath which lies a large orbito-ethmoidal cell.

the air-cells of one or other group develop beyond the boundaries just defined ; thus, superiorly and laterally one or more air-spaces may extend into the orbital plate of the frontal bone, and thus lie posterior to or underneath the horizontal portion of the frontal sinus (*orbito-ethmoidal cells*, Plate *I*, 6), while another may project anteriorly into the medial portion of the floor of the frontal sinus (*bulla frontalis*). In a considerable percentage of skulls there is an extension anteriorly into the ethmoidal crest on the medial aspect of the frontal process of the maxilla ; this constitutes the *cell* or *cells of the agger nasi* (*Fig.* 16). Inferiorly and laterally a cell or cells may invade the orbital plate of the maxilla (*maxillo-ethmoidal cell, Fig.* 13), and, if well developed, will simulate a double maxillary sinus (p. 15). Occasionally, too, a posterior ethmoidal cell is found invading the orbital process of the palate bone (*palato-ethmoidal cell*). Not infrequently the most posterior of the ethmoidal cells grows backwards into the sphenoidal spongy bone and intervenes between the basis cranii and the sphenoidal sinus placed inferiorly (*spheno-ethmoidal cell, Fig.* 16). In these cases the optic nerve may lie in very close relation to the posterior ethmoidal cell. Finally, pneumatization may take place in parts of the ethmoid structure which are not, as a rule, cellular. One or more air-spaces occur in the middle concha, derived either from the anterior or posterior part of the ethmoidal labyrinth (*cellulæ conchales, see Figs.* 15 and 20). These have been found in 20 per cent of skulls (Logan Turner). Rarely, the crista galli of the ethmoid is a pneumatic structure, the cell communicating with the air-spaces of the anterior group.
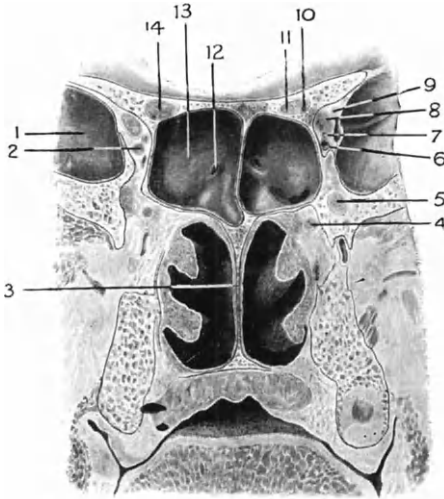
Ostia.—The cell-spaces of the anterior group communicate with the middle meatus through several small openings under cover of the middle concha (*see Fig.* 5) ; the air-spaces of the posterior group open into the superior meatus, superior to the middle conchal attachment, often by one ostium situated at the anterior extremity of the meatus, while a second may be found in the wall of the spheno-ethmoidal recess above the superior meatus (*see Fig.* 5).

The ethmoidal labyrinth, in juxtaposition to the orbit, and separated from it by a thin osseous partition, sometimes perforated by congenital defects, and through which venous channels communicate with the ophthalmic veins, is a possible source of orbital infection, and, indirectly, may be the starting-point of thrombosis of the cavernous blood sinus. Further, through its central position in relation to the other sinuses and its extensions into the bones with which it articulates, the suppurating ethmoid cells may infect the neighbouring air-spaces as a result of the destruction of the partition walls.

The Sphenoidal Sinus (Sinus Sphenoidalis).—The sphenoidal sinus occupies the body of the sphenoid bone. It is sometimes recognized at birth as a small offshoot of the nasal cavity and may attain the size of a bean as early as the 6th year. The cavity is subject to considerable variations and may extend into the basi-occipital, the greater and lesser wings of the sphenoid, and the base of the pterygoid processes. When the sinus is large, its walls are thin and its relationship to a number of the cranial nerves and vessels is correspondingly increased. The clinical

2

importance of the sphenoidal sinus rests mainly upon its contiguity to the inferior surface of the brain and to certain cranial nerves in its immediate neighbourhood.   Thus, in relation to the roof or superior wall lie, from before backwards, the frontal lobe and olfactory tract, the optic commissure, the hypophysis (pituitary body), and sometimes the pons varolii ; while, close to the angle formed by the roof and the lateral wall of the sinus, the optic nerve and the ophthalmic artery pass forwards to the orbit (*Fig.* 17).

The lateral wall is contiguous to the internal carotid artery and the cavernous blood sinus ; in close contact with its anterior part, where it forms the medial boundary of the superior orbital fissure (sphenoidal fissure), are the third, fourth and sixth cranial nerves, and the ophthalmic division of the trigeminus.   The ophthalmic veins pass through the same fissure in their course from the orbit to the cavernous blood sinus.   Piercing the root of the greater wing which projects from the lower part of the lateral aspect of the body of the sphenoid is the foramen rotundum, transmitting the maxillary nerve (superior maxillary division of fifth), and lying posteriorly and slightly lateral to it is the foramen ovale, transmitting the mandibular nerve (inferior maxillary division of fifth).

Fig. 17.—Coronal section through the sphenoidal sinuses and posterior part of the nasal cavities (viewed from behind), showing the relation of some of the cranial nerves to the walls of the sinuses. (1) Middle cranial fossa ; (2) Oculomotor nerve, iii ; (3) Nasal septum ; (4) Nerve of the pterygoid canal (Vidian nerve) ; (5) Maxillary (superior maxillary) nerve, v ; (6) Internal carotid artery ; (7) Abducent nerve, vi ; (8) Ophthalmic nerve, v ; (9) Trochlear nerve, iv ; (10) Ophthalmic artery ; (11) Right optic nerve, ii ; (12) Sphenoidal ostium ; (13) Left sphenoidal sinus ; (14) Left optic nerve, ii.

In relation to *the floor* of the air-sinus, and traversing the root of the pterygoid process, is the pterygoid canal, in which lies the nervus canalis pterygoidei (Vidian nerve) formed by the union of the greater superficial and deep petrosal nerves carrying the motor and sympathetic roots to the sphenopalatine ganglion (Meckel).

The *medial* or *internal wall* is the intersinus septum and, owing to the pronounced manner in which it may deviate from the median plane, the sinus of one side, right or left, may come into close relation with one or more of the cranial nerves of the opposite side, so that heterolateral symptoms and signs may develop in connection with inflammation in one sphenoidal sinus.

The *anterior wall*, vertical in its superior part, inclines downwards and backwards to meet the floor of the sinus.   Its lateral or ethmoidal

portion articulates with the posterior end of the lateral mass of the ethmoid, and completes the ethmoidal cell labyrinth in this situation. In some instances, the inferior part of the anterior wall may form a partition between the sphenoidal and maxillary cavities. Its medial nasal portion contains the opening of the sinus. The *ostium sphenoidale* is situated as a rule in the superior part of the nasal segment of the anterior wall and, therefore, it is not well placed for the drainage of the cavity. Its position varies, however, both in its relation to the floor of the sinus and to the median plane. It communicates with the spheno-ethmoidal recess, situated in the most posterior and superior part of the nasal cavity.

When the sinuses are well developed, their osseous walls are correspondingly thin and, in many cases, dehiscences occur in the bone ; consequently, inflammatory conditions may affect one or more of the contiguous nerves and give rise to visual disturbances, paralysis of orbital muscles, and neuralgia in the distribution of the trigeminus. Septic thrombosis of the cavernous blood sinus and basal leptomeningitis may complicate inflammation in the sphenoidal sinus. The presence of such clinical conditions as the above should draw attention to the possibility of sphenoidal sinus or posterior ethmoidal cell disease as the etiological factor.

METHODS OF EXAMINATION. SYMPTOMS AND GENERAL TREATMENT.

THE USE OF REFLECTED LIGHT.

GOOD illumination is essential for the examination of the cavities of the nose as well as those of the pharynx, larynx and ear. It is therefore important that the student of otolaryngology should, at the outset, become familiar with the use of reflected light. While daylight is occasionally advantageous if one wishes to study the natural colour of the parts affected, it is customary to employ an electric lamp, preferably a 100 watt, gas-filled, frosted-glass globe, enclosed in a lantern fitted with a bull's-eye condenser so as to concentrate the rays, which are then reflected to the area under inspection by a forehead mirror. The lamp is placed close to the left side of the patient's head, that is, to the right of the examiner, and the room should be darkened.

The forehead mirror, provided with a moderate-sized central aperture, should have a focal length not exceeding nine inches, and should be provided with a frontal head-plate which may be secured with a strap and buckle, or the mirror may be attached to a spectacle frame or to a vulcanite band by a ball-and-socket joint. Both of the examiner's hands are thus free for purposes of manipulation. In a patient's house or when the examination has to be undertaken when he is in bed, an electric forehead lamp supplied with a small dry-cell battery will be found most useful.

The observer, having adjusted the forehead mirror so that it lies close to his face, with the aperture opposite his right eye, should seat himself on a stool slightly lower than the patient's chair.

The patient should sit well back in a firm chair facing the examiner. A head rest is often very useful and a footstool will add to the comfort of a patient of short stature.

ANTERIOR RHINOSCOPY.

Some form of nasal speculum must be selected ; of the many varieties devised by different authorities, Thudichum's is the pattern most commonly used in this country. It consists of two metal blades connected by a loop of steel which tends to keep them apart. With the blades towards the patient, the loop should be firmly grasped between the index finger and thumb of the left hand (*Fig.* 18) ; the loop is controlled by pressure between the middle and ring fingers, so that the speculum is

introduced closed and the blades are allowed to separate only by gradual release of the pressure of the controlling fingers. Before introducing the speculum, the anterior nares and vestibule should be inspected. The speculum is then introduced, the patient's head being held erect, i.e., tilted neither up nor down. On the lateral wall of the nose, the eye is at once attracted by a rounded body, red in colour (*Fig.* 19) ; this is the inferior concha.
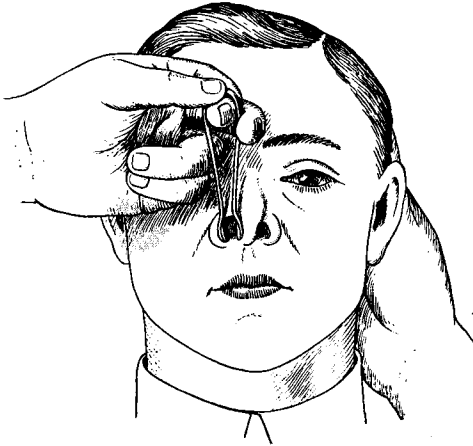
Fig. 18.—Anterior rhinoscopy, with the aid of Thudichum's speculum.
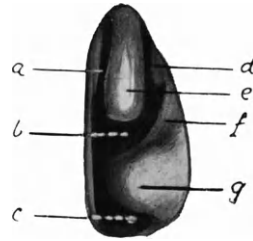
Fig. 19.—Appearances seen on anterior rhinoscopy. (*a*) Sulcus olfactorius ; (*b*) Middle meatus ; c) Inferior meatus ; (*d*) Bulla ethmoidalis ; (*e*) Middle concha ; (*f*) Processus uncinatus ; (*g*) Inferior concha.

If it is small, the observer will realize that he is looking at the anterior end of a ledge which projects into the nose from the lateral wall, and which extends from the front right back to the posterior nasal opening. The passage below this body is known as the inferior meatus of the nose. In many cases the inferior concha is so large that a satisfactory inspection of the nose is not possible, the septum and the anterior end of the concha alone being seen in such cases. The enlargement may be due in part to true hypertrophy, the result of chronic inflammation ; but it is frequently produced by engorgement of the erectile vascular tissue of the concha. In cocaine there is fortunately a drug which enables us to distinguish readily between these two forms of enlargement ; for, on applying a pledget of wool, soaked in a 10 per cent solution, within the nostril, the swelling due to engorgement collapses, while that depending on true hypertrophy remains.

On looking towards the median plane the septum is seen ; in order that a satisfactory view of this structure may be obtained, the patient should turn his head slightly to the opposite side. The septum is rarely quite straight, but is usually more or less deviated and generally presents crests or spurs, a common position for these being parallel with the floor and opposite the inferior concha. In order to see the concha media and the middle meatus, it is necessary for the patient to tilt his head backwards ; the middle concha then comes into view. As a rule the middle concha is narrower in shape and paler in colour than the inferior concha, but it may be enlarged from swelling of the mucosa or from the presence of a large air-cell in the bone (*Figs.* 15 and 20).

Lateral to the middle concha, and between it and the inferior concha, the middle meatus of the nose, which usually appears as a slit, can be recognized.

It is sometimes possible to recognize, in the middle meatus, a fore-shortened ridge in the anterior part, the processus uncinatus; and a rounded body, the bulla ethmoidalis, further back (*see Figs.* 6 and 19).

If the latter is well developed, an appearance is presented as of two middle conchæ, the lateral swelling being the bulla and the medial the real concha media. Between the concha media and the septum is a slit, which is known as the sulcus olfactorius (olfactory cleft).

Fig. 20.—'Cystic' enlargement of right middle concha and deviation of septum to left.

MEDIAN RHINOSCOPY.

THE NASOPHARYNGOSCOPE.

It is not possible by anterior rhinoscopy to see the superior meatus ; in order to obtain a view of these parts, Killian devised a long-bladed speculum which can be introduced between the septum and the middle concha after the induction of local anæsthesia. On opening the speculum, and so pressing aside these structures, a view of the upper regions of the nasal cavity may be obtained. The olfactory cleft may be then explored and the spheno-ethmoidal recess may be inspected. By passing the blades between the middle concha and the lateral wall of the chamber the structures within the middle meatus are brought into view. Holmes's nasopharyngoscope, made on the principle of the cystoscope and introduced along the floor of the nasal cavity, is sometimes used to inspect the upper and posterior parts of the cavity and of the nasopharynx.

POSTERIOR RHINOSCOPY.

The successful performance of posterior rhinoscopy offers the most serious difficulties to the beginner, while even the expert may fail to obtain a satisfactory view. When successful, however, this method of examination is of great value and it should therefore be practised assiduously (*Fig.* 21).

The mirror is simply a small laryngeal mirror. Michel's mirror has a tilting arrangement controlled from the handle, but is difficult to clean

and presents no great advantage. The instruments required are a tongue depressor and a small post-nasal mirror, the former held in the left hand, the latter in the right. Lack's tongue depressor is the best ; it consists of a comparatively narrow metal blade, bent in the middle at right angles. The patient is asked to open the mouth and slightly depress the chin ; the light is then adjusted as usual. The depressor is placed firmly on the dorsum of the tongue just beyond the highest part and gently but steadily applied so as to secure a view of the uvula and of the faucial pillars. A small mirror is more easily manipulated than a large one, but a large mirror will naturally give a wider view and may be used in a tolerant patient who has a capacious nasopharynx.

The mirror, previously warmed to prevent condensation of moisture, and held like a pen, is introduced, with the reflecting surface upwards, behind the soft palate, the patient meantime breathing quietly through the nose. Care must be taken to avoid touching the sensitive mucous membrane of the palate, tongue or posterior wall of the pharynx. Greater steadiness may be secured if the ring finger of the examiner rests on the patient's cheek and the extended little finger supports the patient's chin. The examination is naturally facilitated by the previous application of 5 per cent cocaine solution, but this should be reserved for special cases. The mirror, when in correct position, should be tilted in various directions so as to secure consecutive pictures of the structures in the nasopharynx. First of all, the observer should see the posterior free margin of the septum reflected in the median plane. It is well to look for this first, for it serves as an excellent guide to the geography of the parts,

Fig. 21.—Posterior rhinoscopy.

and it is also advisable always to follow the same order in examining the remaining structures, namely, the roof of the nasopharynx, the lateral walls, including the orifices of the tubæ auditivæ (the Eustachian orifices), and the three conchæ (see Plate III, 4, p. 70).
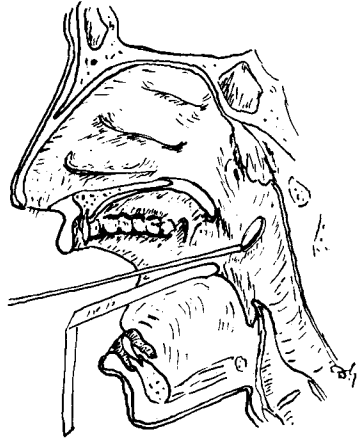
The septum appears as a pale narrow ridge which frequently presents at the centre a symmetrical thickening on either side ; at the upper end it becomes wider and merges into the vaulted roof of the nasopharynx. The latter is pale pink, smooth and thin in the healthy adult, but in the child often furrowed and thickened, from the presence of the pharyngeal tonsil (adenoids—see Fig. 79), which is normally present in childhood.

On the roof, immediately anterior to the posterior nasal opening is the greyish-white fold originally described by W. G. Porter, who suggested that it was the remains of the bucco-nasal membrane. This membrane may persist and constitute the condition known as congenital atresia of the choana (Fig. 22). On each lateral wall, the mouth of the auditory tube

is readily seen by directing the reflecting surface of the mirror laterally. It is on a level with the posterior end of the inferior concha and is bounded behind, above, and in front by a well-marked ridge, the orifice itself appearing as a distinct hollow. This ridge or cushion varies in size considerably in different individuals, and behind it lies the depression called the pharyngeal recess (fossa of Rosenmüller). This recess is frequently filled by a small adenoid mass.

If attention is now directed to the posterior nasal openings, the three conchal bodies may be seen. It will be remembered that, on anterior rhinoscopy, only the inferior and middle conchæ can be inspected, each with its underlying meatus. On posterior rhinoscopy, the superior and
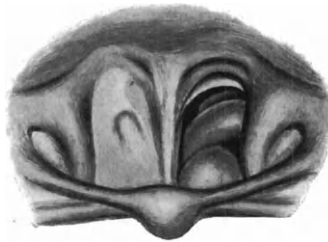
Fig. 22.—Congenital unilateral atresia of the choana; view on posterior rhinoscopy. On the left side the normal appearances are seen. (Note the fold, white in appearance, on the roof of the choana on that side.)

the middle meatuses are visible, but the inferior meatus is hidden from view by the soft palate. From behind, the conchæ appear as greyish-blue bodies, of which the upper two lie diagonally across each choana, while the inferior concha appears rounded, and seems to rest on the soft palate.

It is sometimes impossible to inspect the nasopharynx by the method described above, and in such cases the observer may make use of a palate retractor ; for ordinary occasions, however, this is unnecessary, as sufficient information may be gained by palpation.

DIGITAL PALPATION OF THE NASOPHARYNX.

Palpation is, in many instances, a necessary adjunct to inspection ; and in the anterior nares it may be performed readily, and without discomfort to the patient, by using a slender probe. By this means the mobility of an object, its consistence and its attachment may be ascertained ; the sensibility of the nasal mucosa may also be roughly tested and any sensitive areas detected. Palpation of the nasopharynx is a very unpleasant experience for the patient and should be undertaken only when it is really necessary.

The surgeon having washed his hands, stands behind the seated patient. He holds the patient's head against him with the left arm, and the mouth being open he pushes the fold of the cheek between the upper and lower teeth with his left forefinger so as to prevent biting (*Fig.* 23). He then rapidly inserts his right index finger into the mouth, across the right

tonsillar region and behind the soft palate into the nasopharynx. In this manner he rapidly palpates the roof, the orifices of the auditory tubes and the margins of the choanæ. After some practice he can determine the presence and amount of adenoid vegetations, and recognize

Fig. 23.—Digital examination of the nasopharynx.

any enlargement of the posterior ends of the inferior conchæ, and other pathological conditions.

It is important to remember that, in the absence of adenoid vegetations, the roof of the normal nasopharynx feels quite smooth and firm.

NASAL DEFENCES AGAINST INFECTION.

Before proceeding to enumerate the leading symptoms of nasal disease, it may be convenient to refer briefly to the function of the nose and its means of defence against infection.

Although the nose is the seat of the sense of olfaction its chief function is connected with respiration. The nasal cavity, together with its paranasal sinuses, is lined throughout with ciliated epithelium (*Fig.* 24). In the submucous tissue are numerous glands which constantly secrete mucus, while the middle and inferior conchæ are largely composed of a vascular erectile tissue. Each of those structures has its important function. As the air enters the nose it follows a curved trajectory, ascending to the middle meatus then gradually descending to the nasopharynx. During this transit it is warmed, moistened and filtered by the structures across which it passes. It is warmed by the vascular

conchæ, is moistened by the mucus, which is said to possess bactericidal properties, and is filtered by the action of the ciliated epithelium.

Recent research has proved the importance of ciliary action within the nose. The lining mucosa is covered by a thin layer of mucus, which, by the action of the cilia, is kept moving in the direction of the naso-pharynx. Any interference with the continuity of the mucous coating
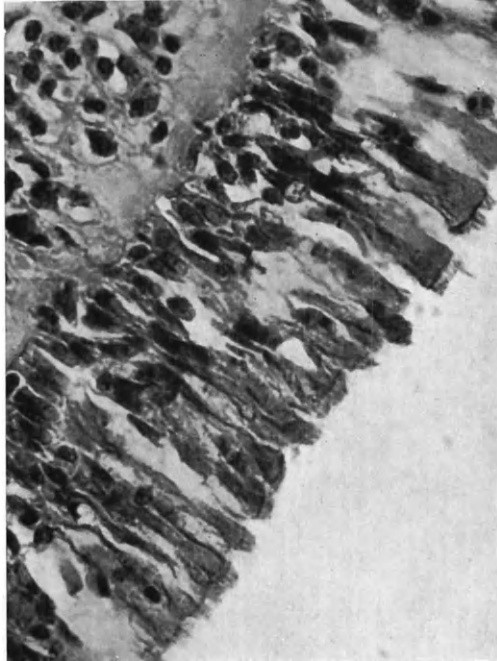
Fig. 24.—Section of nasal mucous membrane showing the pseudo-stratified columna epithelium with well-marked cilia.

or with the action of the cilia will create a point of entry for the organisms which are so numerous in the inspired air.

Cessation of ciliary action is caused by drying, by certain degrees of heat and cold, and by the application of cocaine and of various antiseptics. In treating nasal disease, it is advisable to conserve and to favour, as far as possible, the natural means of defence above described.

SYMPTOMS OF NASAL DISEASE.

While it is not proposed at this present stage to give details of the numerous symptoms of nasal disease, it may be useful to remark briefly upon certain of them, namely nasal obstruction, disturbances of olfaction and of voice, and ocular complications.

Nasal Obstruction.—This is perhaps the commonest symptom of nasal disease. It may affect one or both sides. It may be complete or partial, continuous or intermittent, and may vary in intensity or pass from side to side according to atmospheric conditions. In infants grave symptoms may be produced owing to interference with the act of suckling. In children the habit of mouth-breathing is soon acquired, and the open mouth, high narrow palate, projecting or crowded teeth, vacant expression and pinched nostrils constitute a picture to which the name 'adenoid facies' (*Fig.* 25) is applied, as adenoid enlargement is the most common cause of nasal obstruction in children. The imperfect aeration of the chest in nasal obstruction gives rise to flat chest, round shoulders or pigeon breast. The secondary phenomena of mouth-breathing are of course less frequently found in the adult patient.

Fig. 25.—Typical adenoid facies.

Glossoptosis.—Adenoid facies does not always indicate the presence of adenoids and the open mouth may coexist with nasal respiration. Imperfect development of the lower jaw, favoured by a supine position during suckling, gives rise to the common condition described by Robin as glossoptosis (*Figs.* 26 and 27). The backward position of the tongue

Fig. 26.—Case of glossoptosis.

tends to obstruct the airway, just as may occur during anæsthesia. Opening the mouth tends to draw the tongue forward and is thus the natural means of relieving the obstruction. Nevertheless the air current

continues to take the nasal route. The patient is not a mouth-breather. (*See Fig.* 27.)

Estimation of Nasal Obstruction.—The degree of nasal obstruction may be roughly estimated by asking the patient to close each nostril alternately by the gentle inward pressure of his finger against the ala nasi, when the observer may estimate the volume of the air current during respiration. A visible and more accurate method consists in asking the patient to breathe through both nostrils on to a polished surface such as Glatzel's mirror and noting the size of each area which is dimmed by the condensed moisture. In infants and young children a small wisp of cotton wool held beneath the anterior nares will demonstrate if nasal breathing is present.
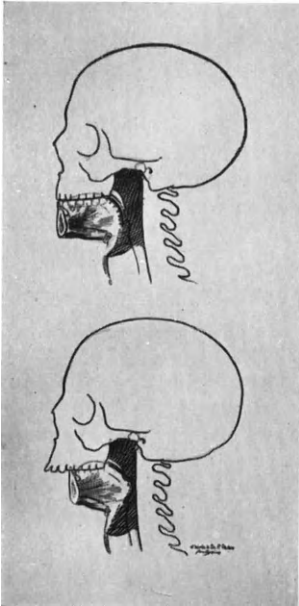
Fig. 27.—**A**, Normal pharynx. **B**, Pharyngeal obstruction (glossoptosis).

Disturbances of Olfaction.—

Anosmia, or loss of the sense of smell, is a common symptom of nasal disease. A sensation of smell can be perceived only when the air-borne odour reaches the mucous membrane of the upper part of the nasal cavity to which the olfactory nerves are distributed. Any cause of nasal obstruction, such as nasal polypi, deviation of the septum or chronic hypertrophic rhinitis, may cause anosmia, and this is perhaps the most frequent cause. Acute rhinitis may temporarily annul the sense of smell, and in atrophic rhinitis the effect may be permanent.

Anosmia may also arise from the inhalation of pungent fumes or from the excessive use of tobacco, and it may occur in influenza. Other causes are fracture of the base of the skull, cerebral hæmorrhage, intracranial tumours and hysteria.

The sense of smell may be tested by volatile oils such as cloves, camphor and asafœtida. Pungent odours, such as that of ammonia, stimulate the common sensation of the fifth nerve and not the special sense of the olfactory nerve. The patient suffering from anosmia fails to appreciate flavours and may, therefore, complain of loss of taste.

Treatment should be directed to the relief of obstruction or of accompanying nasal disease. The internal administration of strychnine has been found useful. Tilley recommends that tincture of iodine be painted on the upper part of the septum by three consecutive applications.

Parosmia, or perversion of the sense of smell, consists usually in the perception of an unpleasant odour (*cacosmia*). As a rule the cause is to be found in nasal sinusitis or tonsillar or dental sepsis, but true cacosmia does exist in influenza, hysteria or epilepsy or in the olfactory hallucinations of insanity.

Hyperosmia, or increased sensibility of the olfactory nerves, may be a symptom of hysteria or of an organic nervous lesion. It may also be associated with nasal allergy (page 57).

Disturbances of Voice and Speech.—The effect of nasal obstruction upon the voice is familiar to all from its association with the common head cold. In this common form of speech defect it is chiefly the nasal consonants which are altered, so that *m* becomes *b*, *n* is changed to *d*, and *ng* to *g*. and speech becomes muffled and lacking in tone owing to the absence of nasal resonance. Further details regarding nasal speech or rhinolalia will be found in Chapter XV, page 111.

Ocular Complications.—Certain affections of the eye are met with as a result of nasal disease ; thus the nasal opening of the tear-duct may become occluded and cause epiphora. Cases of iridocyclitis, blepharitis, conjunctivitis and corneal ulcer which do not respond to careful treatment should have the nasal cavities and paranasal sinuses carefully examined. Serious ocular and orbital complications may be produced in paranasal sinus disease ; these will be discussed later (page 93).

Other symptoms of nasal disease will be described later, in the systematic account of each disease.

GENERAL NOTES ON TREATMENT AND ON LOCAL ANÆSTHESIA.

Only a few general observations need be included under this heading, details being reserved for subsequent chapters.

Nasal Lavage.—Fluids, in large quantities, may be employed for cleansing the nose of crusts or of abundant discharge. The lotions may be introduced either by a Higginson syringe or by a douche-can provided with rubber tubing and a suitable nozzle (*Fig.* 28). In using the douche, the can should be suspended not more than a foot above the patient's head. In either case the patient should sit with the head slightly bent forward over a basin, and should breathe or pant through the mouth. The stream is directed backwards along the inferior meatus and, as the palate contracts, the lotion passes round the posterior free margin of the septum and runs out of the opposite nostril. If one side of the nose is more obstructed than the other, the fluid should be injected only into the narrow side. The patient must not attempt to speak or swallow during the syringing.

Plain water must never be used, nor any strong antiseptic lotion. The solution should be alkaline, and isotonic with the blood plasma. Thus, aqueous solutions of common salt, 9 per cent, bicarbonate of soda, 1·3 per cent or borax, 2 per cent, are isotonic, and are suitable for nasal lavage. The solution should be as warm as can be comfortably borne. A mixture containing all three salts is a favourite formula. (*See* Appendix.) A pint of fluid is usually sufficient, and if a Higginson syringe is used, the force of the stream should not be too great, lest the solution be driven into the auditory tubes and cause infection of the middle ear. When there are no adherent crusts to be dislodged or when the discharge is small in amount the nose may be cleared by a small glass douche or by a coarse spray.

Oily sprays are often of value and require the use of a nebulizer or atomizer. Liquid paraffin is the usual excipient ; the light and less viscous variety should be specified in prescribing, especially in cold climates. Menthol has long been a favourite addition ; chloretone or the various essential oils may be used. (*See* Appendix.)

Steam inhalations may be advised in acute inflammation, especially if affecting the sinuses, and menthol is the medicament most generally employed. A few drops of a 20 to 30 per cent solution of menthol in rectified spirit are added to a jugful of steaming water and the mentholized steam is then inhaled. No special inhaler is required.

Direct application, by means of a wool-dressed probe, is the method of choice when it is desired to use small quantities of a concentrated solution.

Fig. 28.—Method of applying lavage to the nose.

The Technique of Local Anæsthesia. — Local anæsthesia in the nose may be obtained by surface application or injection. For injection, $\frac{1}{2}$ per cent solution of novocain with a few drops of adrenalin may be used. *Cocaine should never be injected.* For examination of the nasal cavities, and before using the galvanocautery, strips of half-inch ribbon gauze or pledgets of wool squeezed out of 10 per cent solution of cocaine hydrochlor., to which has been added a little adrenalin chloride solution (1–100), 10 min. to each drachm of cocaine solution, should be placed in the nose for ten minutes.

When such intranasal operations as submucous resection of the septum, turbinotomy, removal of the posterior end of the inferior concha, intranasal opening of the maxillary sinus, or removal of the middle concha are to be performed, a more thorough local anæsthesia is necessary, and should be carried out as follows : One hour before operation morph. sulph. $\frac{1}{4}$ gr. combined with atropine sulph. $\frac{1}{100}$ gr. should be injected hypodermically. This not only lessens any toxic effect of the cocaine, but has a soothing influence and enables the operator or his assistant to pack the nose with the minimum of discomfort to the patient. Half an hour later the nose should be packed with half-inch ribbon gauze wrung thoroughly out of 10 per cent cocaine with an equal quantity of 1–1000 adrenalin. The gauze should be in one continuous strip for each side. As a rule two drachms of the the solution will amply suffice. The nasal cavities should be packed from below upwards, packing the inferior

meatus from behind forwards in the first instance. At the end of half an hour the nasal mucous membrane is insensitive, and any of the above-mentioned procedures may be performed without discomfort either to the patient or the operator.

Some operators prefer the method of trunk anæsthesia, which consists in the application of a strong cocaine solution to the points at which the principal sensory nerves enter the nose. A pinch of cocaine crystals is moistened with a drop or two of adrenalin and a small quantity of this cocaine mud is applied by a cotton-tipped probe to the mucosa over the posterior end of the middle concha (sphenopalatine ganglion), and also to the upper and anterior angle of the nose (nasal branch of ophthalmic nerve) (see Fig. 9). Anæsthesia is complete in a few minutes and lasts for almost an hour. This trunk method of cocaine anæsthesia may be used to supplement the effect obtained by packing and is useful in the more extensive operations. Advocates of this method claim that it gives perfect anæsthesia and that toxic symptoms are rare.

Cocaine Intoxication.—While there is no drug to equal cocaine as a nasal anæsthetic for surface application, unpleasant and even dangerous results may follow its use. These are best avoided by never injecting cocaine, by limiting the total dose to 1 gr., by the avoidance of swallowing, by the preliminary use of morphine and the combined use of adrenalin, both of which antagonize the toxic effect; and by having the patient in the recumbent position. In small quantities cocaine may produce symptoms resembling alcoholic intoxication, the patient becoming restless, excited and talkative. Should a larger dose be absorbed he feels faint and nauseated, appearing pale, with a rapid pulse and dilated pupils, and he may even have a convulsion or become unconscious.

Cocaine first stimulates, then depresses the respiratory centre. In the stage of depression, respiration assumes the Cheyne-Stokes type and death from asphyxia may follow.

Treatment consists in the recumbent position, the use of smelling salts, fresh air, amyl nitrite inhalation or black coffee. Severe cases may demand artificial respiration, and the use of the strong antidotes, morphine and chloral.

GENERAL HYGIENE.

Climatic and Spa Treatment.—The nasal mucous membrane is peculiarly responsive to atmospheric changes. Temperature, humidity, prevailing winds, sunshine and dust, all have their effects. Change of climate or residence at a spa is an important means of treatment in nasal disorders. Improvement of general hygienic conditions does not entirely explain the success of spa treatment. The local application of the waters by inhalation or spraying has been much used at Continental spas and is now available at Bridge of Allan (chloride water), Bath (radio-active water) and Strathpeffer or Harrogate (sulphur waters).

Heliotherapy.—Exposure of the body to sunlight or to the rays of a carbon arc lamp is a useful adjuvant to other treatment in nasal disease, but the use of the mercury vapour lamp for intranasal irradiation by quartz applicators has not met with such general approval.

CHAPTER III.

THE EXTERNAL NOSE, NASAL ORIFICES AND SEPTUM.

INJURIES TO THE NOSE.

A DIRECT blow on the nose may cause fracture or dislocation of the nasal bones, and this is usually combined with fracture of the septum. Slight lateral displacement of the nose is frequent and bleeding is often profuse. The extent of the injury may not be apparent owing to external swelling. If the patient is seen at once or even within a week of the accident, it is possible to restore the displaced tissue to a normal position by means of Walsham's forceps, or failing this by dressing forceps with blades covered by rubber tubing. General anæsthesia is essential. As a rule no packing or splint is required, but for protection and support a small splint of sheet copper, with adhesive plaster and moulded to fit the nasal bridge, may be worn for a few days.

HÆMATOMA AND ABSCESS OF THE SEPTUM.

Hæmatoma of the septum may be the result of injury or may follow operation. The extravasation of blood causes a smooth rounded swelling which affects both sides of the septum and causes an obstruction just within each nostril (*Plate II*, 4, p. 36). Infection may transform the hæmatoma into an abscess, when the swelling, redness and pain tend to increase. Treatment consists in incising the mucoperichondrium under local anæsthesia, at its lowest part, and evacuating the blood or pus. A gauze drain must be kept in the opening until healing is almost complete as the incision readily tends to close.

DEPRESSED NASAL BRIDGE.

This deformity, sometimes called 'saddle nose', consists in a sinking in of the dorsum of the nose, and it may arise as the result of injury, may follow the healing of a septal abscess or may be caused by the cicatricial contraction of intranasal syphilis. The normal contour may be restored by the subcutaneous implantation of a strip of ivory or, preferably, of a piece of the patient's own costal cartilage, suitably shaped to fill the defect. The graft is introduced through an incision in the columella or across the root of the nose. The operation must not be undertaken in syphilitic cases so long as any active disease is present.

CONGENITAL ATRESIA OF THE CHOANÆ.

This rare condition (*Figs.* 22 and 29) consists in the occlusion of the posterior nares, usually on one side only, by a bony or membranous diaphragm. The symptoms are those of nasal obstruction but are sometimes very slight. Posterior rhinoscopy, the failure to pass a probe along the floor of the nose into the nasopharynx or digital palpation will establish the diagnosis, and the treatment, if necessary, consists in the removal of the obstruction together with a portion of the adjacent posterior margin of the septum.

DERMATITIS AND FURUNCULOSIS OF THE NASAL VESTIBULE.

This is often the result of nasal discharge, and calls for a careful investigation of the nose and sinuses. There is redness, excoriation and fissuring of the skin within

Fig. 29.—Congenital bony atresia of right choana. The left choana is patent, and its bony margins are larger than those on the right side. (Seen from behind.) Dr. J. S. Fraser's case.

and around the nostril, and the crusts which form may cause obstruction.

TREATMENT consists in the removal of the crusts and painting with nitrate of silver solution (20 gr. to 1 oz.) followed by the use of a mild mercurial ointment. An ointment containing sulphur and salicylic acid is also useful (*see* Appendix).

Occasionally a deeper infection of the skin occurs, with the formation of a painful furuncle. If this is neglected or irritated, as by an attempt to squeeze out the contents, it may even lead to a fatal thrombosis of the cavernous blood sinus which becomes infected by way of the angular and orbital veins. Hot fomentations and the local application of magnesium sulphate paste or of 10 per cent ichthyol in glycerin will usually effect a cure, while recurrences may be avoided by a course of autogenous vaccines.

DEVIATIONS AND SPURS OF THE SEPTUM.

It has already been pointed out that a perfectly straight septum is but rarely found and, even when the septum is straight, it frequently has a ridge or spur upon it. Deviations of the septum and spurs may be very slight, or so marked as entirely to block one cavity. In some forms of deviation, notably those which assume an S shape, both sides may be blocked, the obstruction being anterior in one cavity and far back in the other nasal cavity. Individuals vary greatly in the degree in which they suffer from an apparent blocking of the nose from septal deviation. In some in whom the obstruction is but slight there may

be pronounced symptoms, while others make no complaint although one nostril is almost completely blocked. It is accordingly necessary to be guided largely by the subjective symptoms in deciding as to the advisability of operative interference. Deviations may be developmental in origin, in which case they present a C or S shape, or they may result from trauma. The latter may also be C-shaped, or they may be irregular, depending on the line of fracture of the septum. The tip of the nose may be twisted to one side in all varieties of deviation. It is frequently impossible to decide whether a deviation is developmental or traumatic, but the matter is of no clinical importance.

APPEARANCES. — In C - shaped deviations (*Fig.* 30) the septum presents a convex surface on the narrow side, while the other nasal cavity appears unduly patent. The inferior concha is frequently enlarged on the concave side. The anterior edge of the septal cartilage is sometimes dislocated, so that it projects into and partially blocks the vestibule of the patent side of the nose.

Fig. 30.—Simple angular deviation of septum nasi to the left.

Deviations are frequently associated with crests or ridges on the septum. The most common situation for these is along the line of the upper edge of the vomer, beginning in front at the anterior nasal spine and running upwards and backwards (*see Fig.* 7). These crests may be so large as to be in contact with the inferior concha in its anterior part.

SYMPTOMS.—Deviations and spurs of the septum may be unassociated with symptoms, but in other cases nasal obstruction, either unilateral or bilateral, is complained of.

Neuralgia of the supra-orbital or infra-orbital branches of the trigeminal is frequently associated with a spur on the septum in persons over forty. A type frequently seen is a pointed vomerine spur, at the junction of the middle and posterior third of the septum, pressing against the inferior concha. Neuralgia of the supra-orbital is frequently associated with a deviation high up on the septum, usually in the S-shaped variety. The deviation may press on the anterior end of the concha media, causing congestion of the underlying parts and leading to intermittent closure of the nasofrontal duct. The air in the frontal sinus becomes absorbed and a vacuum in that sinus is produced, resulting in neuralgic headache, which is aggravated by near accommodation (Sluder). The headache may be temporarily relieved by the application of 5 per cent cocaine to the anterior end of the concha media.

DIAGNOSIS.—This can easily be made by inspection.

TREATMENT, if necessary, is operative, and every class of deviation can be satisfactorily dealt with by the operation of submucous resection of the septum. The operation is usually performed under local anæsthesia. No after-treatment is necessary, and the patient only requires to lie up for three or four days. The principle of the operation consists in removing the deviated cartilage and bone without destroying the

mucous membrane on either side.   Anæsthesia of the septum and nasal cavity having been obtained by the method described on page 30, an incision is made through the mucoperichondrium down to the cartilage but not through it.   It extends from the anterior angle of the nose to

Fig. 31.— Operation for deviated septum. Elevation of mucoperichondrium.

the floor just posterior to the mucocutaneous junction. With a small flat elevator the mucoperichondrium is separated from the septum over the whole extent of the deviation, not only of the cartilage, but also of the bone (*Fig.* 31).   The incision is now carried through the cartilage as far as but not through the

Fig. 32. — Operation for deviated septum.   Long-bladed speculum in position.

mucoperichondrium of the other side.   The elevator is carefully inserted through the cut edge of the cartilage so as to elevate the opposite mucoperichondrium, which is stripped up in a similar manner.   The small speculum through which the operation has been conducted so far is now removed, and a long-bladed Thudichum's speculum inserted so that the rigid septum is contained between the blades, and the two mucoperichondrial flaps are held apart by the outer surfaces of the blades (*Fig.* 32).   The cartilaginous deviation is then removed with the aid of Ballenger's swivel knife ; the deviation in the bony septum is removed by punch forceps (*Figs.* 33, 34) ; and finally,
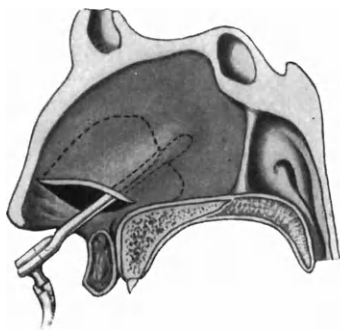
Fig. 33.—Operation for deviated septum. Removal of bony deviation by cutting or punch forceps.
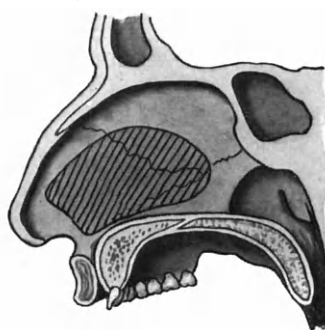
Fig. 34. — Operation for deviated septum. The shaded portion shows the area of denuded cartilage to be removed by Ballenger's knife and the area of bone to be removed by forceps.

after a little further dissection and clearing, the bony spur is taken off by means of hammer and chisel.   The long-bladed speculum is now withdrawn and the flaps fall together.   It is unnecessary to stitch the cut edge of the flap if it is carefully approximated and held in position by means of rubber finger-stalls lightly distended by ribbon gauze. Before being placed in the nose, the finger-stalls should be dipped in

sterile liquid paraffin. They should be removed at the end of twenty-four hours and not replaced.

The patient who has undergone submucous resection of the septum should be warned of the deformity which may follow a blow on the nose before the tissues have entirely consolidated. For this reason he should not indulge in boxing, football, etc., for some months after the operation.

In children, as the result of falls against projecting objects, the septal cartilage is frequently dislocated out of its groove between the maxillæ and premaxillæ. These cases, if seen early, are amenable to treatment and much after-trouble and deformity are saved. It is possible under general anæsthesia to replace the septum in its groove and maintain it in position for forty-eight hours by suitable packing.

PERFORATION OF THE SEPTUM.

The septum may become perforated as a result of syphilis, lupus, trauma, or a perforating ulcer. It occasionally occurs also in typhoid and other fevers, or may be the result of chemical irritants such as chromic acid, copper and arsenic. The perforations due to syphilis are considered later (p. 51). Traumatic perforations are generally the result of operations for the removal of septal deviations. They do not, as a rule, cause inconvenience, especially if they are situated far back. When they are small, and near the front, they may produce a whistling sound when the patient breathes through the nose, and this may cause considerable annoyance. If the perforation is large, there may be a tendency to crust-formation for some months after operation.

Perforating ulcer of the septum is idiopathic in origin, and affects the cartilaginous part of the septum, close to the anterior nares. Before the ulcer develops, a small scab appears in this region, which is usually picked off by the patient, but another soon forms. The process tends to be repeated frequently, until finally a small, sharply-defined ulcer forms under the scab. It gradually becomes deeper and erodes and perforates the cartilage and the mucous membrane of the opposite side of the nose, thus forming a perforation. The edges of the perforation then rapidly clean up and heal, leaving the patient with a small, dry, circular or oval perforation in the cartilaginous part of the septum, of which he is probably quite unconscious (*Plate II*, 5).

DIAGNOSIS.—It is not probable that a mistake will be made in the diagnosis of this condition, as the appearances are very characteristic. The localization of the ulcer, its limitation to the cartilaginous part of the septum, and the absence of inflammation about it, are features which differentiate the condition from lesions due to syphilis or lupus; while the fact that, after perforation has occurred, the edges are thin also helps to distinguish it from the perforations of syphilis and lupus, in which the edges are thickened.

TREATMENT.—If the condition is seen before perforation has taken place, the patient should be enjoined not to pick the nose, and the ulcer can occasionally be made to heal if it is painted with silver nitrate. After perforation has occurred, all that can be done is to keep the parts clean and so favour healing of the edges.

PLATE II

AFFECTIONS OF THE NOSE
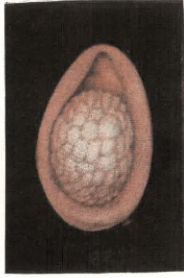
1. Enlarged anterior end of inferior concha (right).

2. Nasal polypus.
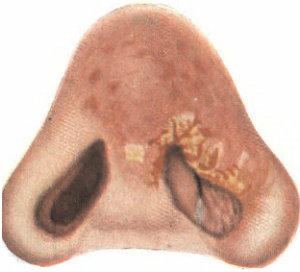
3. Lupus of nasal mucosa and skin.
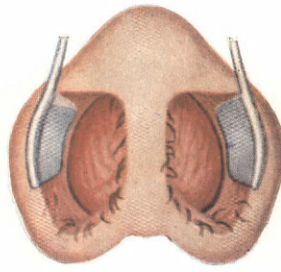
4. Hæmatoma of septum.

5. Anterior septal perforation.

6. Bleeding area of septum.

CHAPTER IV.

INFLAMMATORY DISEASES.

ACUTE RHINITIS.

ACUTE rhinitis, or cold in the head, is a condition familiar to all from personal experience. It is especially prevalent in the spring and autumn, and is liable to occur after exposure to wet and cold. It is met with in the course of the exanthemata, especially measles, and occurs in influenza. It may result from the ingestion of certain drugs, such as iodide of potassium, while a dusty atmosphere or chemical irritants also predispose to this condition. In spite of its common occurrence, the etiology is still uncertain ; and although the affection is undoubtedly contagious, inoculation experiments almost invariably fail to produce it.

SYMPTOMS.—A fit of sneezing often ushers in an attack ; the nose then becomes blocked, one side being as a rule affected before the other. Loss of the sense of smell, headache and a feeling of chilliness accompany the nasal obstruction, which is also associated with a profuse discharge from the nose ; this is at first watery, but later becomes mucopurulent, and then purulent. After a few days the discharge gradually subsides. The process may spread to the pharynx and the larynx, or the nasal condition may be secondary to an inflammation of these parts. The hearing may also become impaired through temporary Eustachian obstruction. In infants, the obstruction due to a simple coryza may be a serious danger, as both feeding and sleep are interfered with.

APPEARANCES.—On examination of the nose, the mucosa is found to be red and swollen, and the nasopharynx and pharynx may present a similar appearance.

TREATMENT.—If treatment is desired, it is advisable in the early stages to give the patient a very hot bath at bedtime, and induce perspiration by the exhibition of aspirin, gr. 10. Local applications to the nose, in the form of snuffs or sprays, may also be prescribed to relieve the nasal obstruction ; menthol in liquid paraffin, or an oily solution of ephedrine, may be found serviceable for this purpose (see also Appendix). Local application of cocaine to relieve congestion and encourage drainage should be made only by the medical attendant. Its effect can be considerably prolonged by spraying the nose with a 2 per cent solution of antipyrin after application. Vigorous blowing of the nose should also be avoided, as it is associated with a risk of infecting the middle ear. In some cases, an attack may be shortened by the injection of a suitable vaccine. A bacteriological examination of the discharge should be made at an early stage of the infection, to discover the causal organism.

Vaccines have also been found useful as a means of checking the

tendency to frequent colds in the head which afflicts some people. Logan Turner and Bolton obtained good results in this way from autogenous vaccines, and their acute cases seem to have been due to staphylococcus or pneumococcus, while other observers have found streptococcus, *M. catarrhalis*, *B. influenzæ*, *B. septus*, and *B. Friedländer*. While the autogenous vaccine is being prepared, relief may be given to the patient by the injection of a suitable dose of one of the stock coryza vaccines.

Another and simpler method of treatment may, however, be effective in many cases. It will often be found that those who suffer from frequent colds lead unhealthy lives. They frequently spend most of their time in hot, ill-ventilated rooms, commit dietetic indiscretions both as to solids and liquids, while they are out of condition generally owing to lack of fresh air and exercise. A more careful diet, methodical exercises, including deep breathing, either in the open air or before an open window, and sleeping in a room with an open window, will often work wonders.

Purulent Rhinitis is a form of acute rhinitis which may be produced by direct contact with gonorrhœal secretion but usually arises in the course of one of the exanthemata, more especially measles. The symptoms are similar to those of the simpler form, but are more acute. The discharge is purulent and very profuse, and is probably the initial stage of atrophic rhinitis. Frequent lavage of the nose by weak antiseptic lotions is all that can be done in the way of local treatment, but a suitable vaccine may be employed. The condition is fortunately a rare one.

Fibrinous Rhinitis is characterized by the formation of a false membrane on the nasal mucosa, and is always associated with the presence of the Klebs-Löffler bacillus.

SYMPTOMS.—The symptoms are those of nasal obstruction and discharge, combined in many cases with epistaxis. The discharge may be clear and watery or thick and yellow, and causes considerable excoriation of the anterior nares and upper lip. The condition causes little or no constitutional disturbance, and the patient, usually a child, is brought for treatment on account of nasal obstruction which has continued for some time. The condition is highly infectious, but according to Lack does not give rise to true diphtheria ; other observers, however, have reported the contrary. It lasts for many weeks and leaves no sequelæ.

Examination shows the mucous membrane of the inferior and middle conchæ and septum to be covered by a greyish membrane which is somewhat difficult to remove, and leaves a bleeding surface behind it on which the false membrane soon re-forms. The membrane is microscopically indistinguishable from diphtheritic membrane and bacteriologically exhibits true diphtheria bacilli ; and it is advisable to carry out the virulence test in these cases.

TREATMENT.—The patient should be isolated. The nose should be douched with mild antiseptic and cleansing lotions, e.g., boric, saline, or phenol sodique (*see* Appendix, PHARYNX). If adenoids are present they should be removed, after a protective dose of 500 units of antitoxin, although the administration of antitoxin *per se* cannot be said to clear up the condition. The patient should be kept in isolation until the nose is clear of diphtheria bacilli, as shown by at least three negative swabs.

CHRONIC RHINITIS.

Chronic rhinitis will be considered under the following headings : (1) *Chronic hypertrophic rhinitis* ; (2) *Chronic atrophic rhinitis* ; (3) *Rhinitis sicca.*

1. Chronic Hypertrophic Rhinitis may result from repeated attacks of acute rhinitis. Predisposing factors are constant exposure to a damp or dusty atmosphere, or to chemical irritants. It is frequently met with in patients suffering from paranasal sinus suppuration, from adenoid vegetations, or from marked septal deformity. In some cases it seems
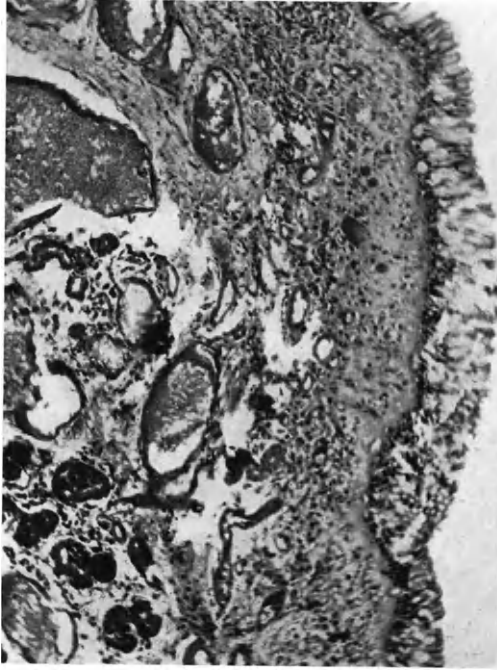
Fig. 35.—Section of inferior concha in chronic hypertrophic rhinitis, showing: (*a*) Lining of pseudo-stratified columnar ciliated epithelium ; (*b*) Goblet mucous cells; (*c*) Lymphocytic infiltration of subepithelial connective tissue ; (*d*) Ducts of mucous glands; (*e*) Large dilated vessels of cavernous venous plexus. (× 240.)

to be associated with a gouty diathesis, while in others it may be attributed to the excessive use of alcohol or tobacco.

SYMPTOMS.—One of the chief symptoms is nasal obstruction ; this varies greatly in different individuals and at different times, but is nearly always more pronounced at night. Associated with the nasal obstruction there is generally some impairment of the senses of smell and taste ; a change in the voice is also noticeable when the obstruction is very marked. Increased secretion is another important symptom, and it may be very troublesome. The discharge is generally watery or viscid in character and free from odour.

APPEARANCES.—On anterior rhinoscopy, the mucosa presents a congested appearance and portions may also be hypertrophied (*Fig.* 35). The enlargement may involve the inferior concha ; in that case the anterior end may be specially affected (*Plate II*, 1, p. 36), or a fringe-like overgrowth may be seen extending along the whole length of this structure, or the posterior end alone may be thickened (*Plate III*, 5, p. 70) ; the swollen part has frequently a mulberry-like appearance which is best seen on posterior rhinoscopy. The middle concha is not so often affected as the inferior, nor does it become hypertrophied to such a degree. Before making a diagnosis of true hypertrophy, it is necessary to apply a solution of cocaine (5 to 10 per cent). This removes the swelling due to vascular engorgement, while the enlargement due to thickening is unaffected. In almost every case some shrinkage takes place.

TREATMENT.—The treatment varies with the severity of the symptoms and with the pathological condition found. The practitioner should not be in too great a hurry to operate, for if there is unnecessary inter-ference, not only may no benefit result, but a great deal of harm may be done, and an atrophic condition may be set up, associated with crust-ing, which is much more distressing to the patient than the symptoms produced by the hypertrophy. In the milder cases, an attempt should be made to relieve the symptoms by the use of nasal sprays, such as salt solution, bicarbonate of soda, or borax (*see* Appendix). When this treatment is unavailing, or when the hypertrophy is well marked, it is advisable, after the induction of local anæsthesia, to remove the thick-ened parts by means of scissors and snare. Too much tissue must not be taken away, and the amputation of the whole inferior concha is never justifiable. When the enlargement is limited to the anterior end of the inferior concha, it may be possible to grasp it by means of the snare alone ; but if this fails, a cut should first be made into that structure with a pair of scissors, and the portion so separated should then be caught up by the snare and removed (*Figs.* 36, 37). If there is a fringe of hypertrophied
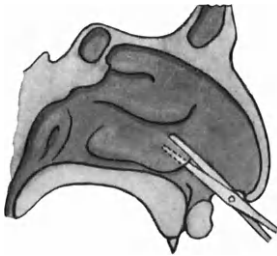
Fig. 36. — Conchotomy. Scissor cut in anterior end of hypertrophied inferior concha.

tissue along the whole of the lower border of the inferior concha, it can be removed by the scissors alone. Hypertrophies of the posterior end of this structure are more difficult to deal with, and a snare is more suitable for their removal. It does occasionally happen, however, that after the induction of local anæsthesia the enlarged posterior end is so shrunken that it is impossible to grasp it in the snare loop. This difficulty may be overcome by in-jecting the inferior concha far back with normal saline. The effect of this injec-tion is to balloon the collapsed posterior end and render its ensnarement easy. When caught in the snare, the loop is slowly tightened and then jerked gently backwards towards the nasopharynx (*Fig.* 38). This disengages the posterior end without stripping the inferior surface of the concha, which is apt to occur if

the snare is jerked forward in the first instance. Hypertrophies of the middle concha should also be attacked by means of a snare.

When circumstances permit, the patient may be sent to a spa, such as Bridge of Allan, Bath, or Harrogate, where local treatment by sprays or inhalations is available and is a useful supplement to the general hygienic régime.

2. Chronic Atrophic Rhinitis may or may not be associated with fœtor. In the former case it is commonly known as ozæna.

Fig. 37. — Conchotomy. Introduction of the snare loop over the cut end of the hypertrophied concha.

Ozæna.—The etiology of ozæna is still uncertain, and numerous theories have been advanced as to the cause of this disease. Grünwald believes that every case of ozæna is the result of local disease in one or other of the paranasal air sinuses, and that failure to find the focus is due to lack of skill on the part of the investigator. It has, however, been proved that this rule is not universal, although certain cases of ozæna are associated with suppuration in the paranasal sinuses. It is now generally admitted that ozæna is the terminal stage of chronic purulent rhinitis. This may arise as the result of infection of the nasal mucosa by the gonococcus, but is more commonly the sequela of measles or scarlet fever.

Adam has recently published a series of cases in support of Grünwald's view, and has stated that the affection usually begins before puberty and that sinusitis is present in more than half the cases. He contends that the more frequent removal of adenoids has reduced the incidence of ozæna, which has already become a relatively rare disease.

The majority of observers deny that syphilis or tuberculosis play any part in the causation of ozæna. Many organisms have been isolated by Abel, Perez, and others, but the data are unconvincing, and it is difficult to say whether the organism causes the disease or is responsible only for the fœtor.

Fig. 38. — Conchotomy. Snare loop encircling the hypertrophied posterior end of the inferior concha.

The pathological changes consist in progressive atrophy of the mucosa and the underlying bone of the conchæ, and a conversion of the ciliated epithelium to cubical or stratified squamous epithelium ; ulceration does not take place The mucous membrane exudes a thick viscid secretion which dries rapidly and forms crusts which emit the characteristic and horrible odour of ozæna. Ozæna occurs chiefly among the poorer classes and especially in anæmic and ill-nourished individuals ; it is much more common in women than in men and usually begins about the time of puberty. As a rule, both sides of the nose are affected, but in some cases the disease is unilateral.

SYMPTOMS.—The most characteristic symptom is the loathsome

fœtor ; this varies considerably in intensity and in some cases the odour increases during menstruation ; it is sometimes so strong that it is impossible for anyone to stay in the same room as the patient, and it has a peculiar bouquet, which to many observers is pathognomonic. The patients fortunately cannot themselves detect any smell ; in fact, they often suffer from complete anosmia. The fœtor arises from the crusts which form within the nose, and which are also the cause of the second important symptom—nasal obstruction. Frequently headaches are complained of, and a feeling of dryness in the nose and throat. The crusting occasionally extends into the nasopharynx and the pharynx, and sometimes even involves the larynx and trachea. The crusts are dislodged from the nose from time to time, and may be discharged in the act of blowing the nose, or may find their way into the pharynx. Spontaneous epistaxis sometimes occurs, probably induced by the separation of the crusts.

APPEARANCES.—In examining the nose in a well-marked untreated case of ozæna, the nasal cavities are found to be filled with greenish crusts and, on posterior rhinoscopy, the vault of the pharynx may also be seen to be clothed with dried secretion. When the crusts have been removed after the method shortly to be described, the unusual size of the nasal cavities at once strikes the observer. The inferior and middle conchæ may be very markedly atrophied, so that a ready view is obtained of the middle meatus, the uncinate process and the bulla ethmoidalis, while the margins of the choanæ, the auditory tube, the posterior wall of the nasopharynx, and the movements of the soft palate are all clearly visible from the front. As a rule the diagnosis is not difficult, but care must be taken to exclude paranasal sinus suppuration. The absence of ulceration will serve to distinguish ozæna from tertiary syphilitic lesions.

PROGNOSIS.—It is not within our power to cure ozæna, though cases of spontaneous recovery are met with ; but it is always possible by suitable treatment to prevent the crusting, and so keep the main symptoms of the disease in abeyance, i.e., the fœtor and the nasal obstruction.

PROPHYLAXIS.—In view of what has been said above regarding the causation of ozæna, every endeavour should be made to cure purulent rhinitis arising in cases of measles and scarlet fever. Every case should be most carefully examined under cocaine and adrenalin, if necessary, so that air-cells secreting pus may be effectively drained and even surgically opened. The purulent secretion should be examined bacteriologically and a suitable vaccine prepared, since experience has shown that there is a favourable response to vaccine treatment.

TREATMENT.—The treatment still consists in the main in cleanliness, for none of the so-called cures of this affection have stood the test of time. The following is the method which should be employed for removing the crusts : In the first place, the nostrils are plugged by means of a tampon of gauze or cotton-wool, which the patient may be taught to introduce himself with a pair of forceps ; if a wick of cotton-wool is used, it is pushed into the nose with a screwing motion ; the anterior nasal orifices should be packed as tightly as possible. On removing the plugs,

which should be allowed to remain in place for about half an hour, many of the crusts will probably come away. The nose is then syringed with normal saline solution or weak boric lotion (1–60) ; strong antiseptic solutions should be avoided. This procedure alone is sufficient to keep the symptoms in abeyance, and more than this cannot be achieved by any method of treatment. In severe cases it has to be repeated once or twice a day, but the patient will soon find out for himself how long an interval may be allowed to elapse between successive syringings. When the fœtor is very intense, it is advisable to paint the inside of the nose with Mandl's paint (*see* Appendix, PHARYNX) after syringing.

It is hardly necessary to detail other methods of treatment, but it may be mentioned that massage within the nose, and the insufflation of powders, such as iodol or aristol, have been tried. Treatment by cupric electrolysis was at one time greatly in vogue, but it has now been abandoned. Attempts have also been made to improve the condition by submucous injections of paraffin into the conchæ and septum. The suction method of producing hyperæmia has also been adopted, and apparently the nose may be freed from crusts in this way. When one or more of the paranasal sinuses are diseased, appropriate treatment should be adopted.

As an alternative to douching, anointing the mucous membrane with an ointment consisting of ichthyol 20 gr., menthol 2 gr., and petrolatum 2 oz., lessens the unpleasant symptoms (Fowler).

The direct application to the nasal cavities of a mixture containing 25 per cent glucose in glycerin has met with some success. The idea underlying this method is that the growth of inimical bacteria, e.g., Perez's bacillus and *B. mucosus capsulatus*, is hindered and finally checked by altering the chemical constituents of the medium on which they thrive. Such a result is obtained by saturating the nasal mucous membrane with glycerin and glucose. The Perez's bacillus has only a very weak action on sugar. At the same time this medium encourages the growth of less harmful bacteria. In time the bacterial flora becomes changed, the fœtor disappears and the crust formation is greatly reduced. The mixture should be applied five or six times a day. It should be thoroughly rubbed into the mucous membrane on probes covered with cotton-wool. At first, it is better that the treatment should be carried out by the medical attendant ; but later, as the applications become less frequent, it may be entrusted to the patient.

Operations performed with the object of narrowing the nasal cavities have been devised. Inward displacement of the entire lateral wall of the nose (Lautenschläger's operation) and submucous implantation of cartilage into the septum or floor of the nose, are said to have produced good results.

3. **Rhinitis Sicca.**—Although not generally recognized as a separate disease entity, this term is employed to denote a condition met with usually in those whose occupation compels them to work in hot, dry, and dusty surroundings, viz., rubber-workers, bottle-blowers, furnacemen, bakers, and bakers' shop-girls. It is also met with in plethoric individuals

addicted to alcohol and tobacco, and in females about the age of puberty, the subjects of anæmia and constipation.

SEMEIOLOGY.—The patient usually complains of dryness and stiffness in the nose, combined with occasional epistaxis following the expulsion of small, thin crusts. There is no fœtor.

APPEARANCES.—The mucous membrane shows dark-red congestion and is firm to the probe. Hair-like bridges of sticky secretion run between the conchæ and the septum. Little dry crusts adhere in places, and there is often a small excoriation on the septum, just internal to the vestibule, due to nose-picking. The epistaxis has its origin here. A similar condition may be present in the pharynx and larynx.

TREATMENT.—This is general and local. Anæmia, constipation, and excesses in alcohol and tobacco should receive attention. Locally, warm alkaline douches, as in the method recommended for ozæna, to get rid of the sticky secretion, and thereafter the application of an oily substance such as liquid paraffin, or Mandl's solution, to the nasal mucous membrane may be employed.

CHAPTER V.

NASAL POLYPUS.

PATHOLOGY AND ETIOLOGY.—The name polypus, or mucous polypus, is applied somewhat loosely to a projection of œdematous mucous membrane which is in no sense a new growth. It is composed of loose fibro-œdematous tissue and the free surface is clothed as a rule with ciliated epithelium; small blood-vessels traverse the swelling and are sometimes seen on its surface. There is a variable degree of round-celled infiltration.

The underlying bone is affected, though it is uncertain whether this infection is primary or secondary. St Clair Thomson inclines to the view that pathological secretions of all kinds in the nose are the chief cause of nasal polypi. Though rarely found in childhood or youth, except in the form of the large solitary naso-antral or choanal polypus, nasal polypi are extremely common in adult life and are commoner in men than in women.

Any condition of hyperæmia or inflammation within the nose may give rise to polypus formation. Polypi may

Fig. 39.—Nasal enlargement; the result of neglected polypi.

accompany chronic rhinitis, sinus suppuration, malignant disease, and allergic conditions.

SITE OF ORIGIN.—The ethmoidal region is the part most frequently affected. The polypi, which may be pedunculated or sessile, arise almost always from the lateral wall of the nose, being attached to the middle concha or to the margins of the hiatus semilunaris, under cover of the concha, and in some cases the ethmoidal cells are filled with numerous sessile polypi. Sometimes the pressure of the œdematous masses distends

the nasal cavity and causes an obvious broadening of the external nose (*Fig.* 39).

SYMPTOMS AND SIGNS.—The leading symptom is nasal obstruction, but its onset may be so gradual as to pass unnoticed by the patient. He may complain of headache, of watery discharge from the nose, and of loss of the sense of smell. Sometimes there is a sensation as of a foreign body in the nose, and in neglected cases the polypus may be so close to the nostril as to attract the attention of the patient (*Fig.* 40).

On examination, the smooth, glossy, movable, bluish-grey swelling presents a characteristic appearance, but sometimes the colour is pink or red and the swelling may then be mistaken for an enlarged concha.

Fig. 40.—Nasal polypus.

The use of the probe, however, will demonstrate the soft, mobile, and insensitive nature of the polypus. It may be necessary to shrink the tissues by the application of cocaine and adrenalin in order to obtain a satisfactory view.

TREATMENT.—This consists firstly in the removal of the polypi together with the small area of bone to which they are attached, and secondly, in the cure of any accompanying infection of the paranasal sinuses. Large polypi may be satisfactorily removed by the wire snare. Of the numerous snares in use, Blake's pattern is still most generally employed. It is threaded with piano wire, which should not project at all when the snare is drawn home, otherwise the snared tissue is liable to slip out. The wire should not pass into the tube of the snare when closed, as the object of snaring is to tear the polypus, together with its base, and not to cut through the pedicle. Unless the patient be a very nervous subject, nasal polypi may be satisfactorily removed under local anæsthesia (*see* p. 30). The snare loop is first held vertically and is passed alongside the polypus. Then the loop is made to encircle the swelling and is worked upwards by a side-to-side movement until the point of attachment is reached, when the snare is closed, and withdrawn by a quick jerk. Other polypi are dealt with in like manner either at the same sitting or subsequently. Hæmorrhage is usually brisk but soon ceases, and packing is seldom necessary.
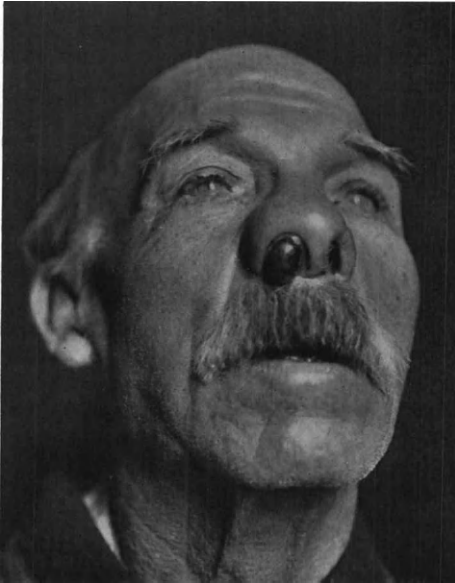
When only a few polypi are present, and when there is no accompanying sinus infection, the above procedure may establish a cure. As a rule, however, it is necessary to remove the diseased areas of ethmoid bone and to deal with infection of the neighbouring paranasal sinuses. The latter is described under the respective heading. The former is accomplished either by the use of Luc's or Blakesley's forceps, or by the more risky procedure known as Sluder's operation. Sluder recommended that his hook-shaped knife be used to remove the middle concha close to the cribriform plate and subsequently to break down the walls of the underlying ethmoidal cells. This procedure involves the area which Burger has termed the danger zone of the nose (*Fig.* 41), and although the result may be excellent in skilled hands it is perhaps wiser to adopt the safer plan of removing the diseased ethmoid by nasal forceps, working under cover of the middle concha, which is retained as an important anatomical landmark. The forceps are passed beneath the concha, and the polypoid tissue and bony laminæ are removed piecemeal. Grünwald's biting forceps may be employed to complete the operation. The field of operation should be kept under direct vision and any blind thrusting movement of the forceps is to be avoided. Although hæmorrhage will obscure the view, it is, as a rule, readily controlled by temporary packing. Ethmoidal curettage by means of Meyer's ring knife is preferred by some.
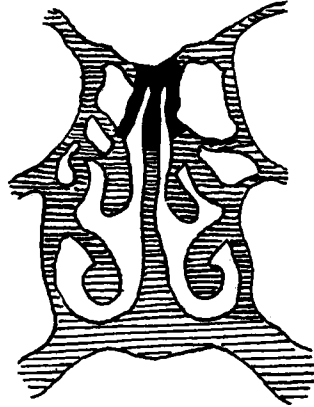
Fig. 41.—The 'dangerous area' of the nose. (Burger.)

AFTER-TREATMENT.—The patient should remain in bed for forty-eight hours, and should be warned to avoid blowing his nose, as emphysema of the upper and lower eyelids may result. On the day following operation a warm alkaline nasal douche will remove crusts and add to the comfort of the patient, but this should not be repeated. Daily inhalations of mentholized steam may be given, and the formation of crusts may be kept in check by the injection into the nose of a few c.c. of liquid paraffin (with $\frac{1}{2}$ per cent menthol or phenol) or by the use of a mildly antiseptic ointment. The nose should be carefully inspected in a week or ten days so that any small polypi or tags which have escaped attention may be removed.

CHAPTER VI

NEW GROWTHS.

THESE may be either simple or malignant; the latter are the more frequent.

Simple Tumours.—

Papilloma and Fibroma are rare. They may grow from the septum—which is the usual site of the papilloma—from the inferior concha, or from the floor of the nose, and give rise to nasal obstruction and occasional epistaxis. On the lateral wall of the nose they may cause blockage of the tear duct and epiphora. Microscopically they do not differ from similar tumours in other situations. If small, they may be removed by a combination of submucous resection and avulsion by the snare. If they are large, an external operation may be unavoidable. After removal, a microscopical examination should be made in order to exclude evidence of commencing malignancy.

Angioma (Bleeding Polypus of the Septum).—This also is a somewhat rare condition. It was supposed at one time that a bleeding polypus was one of the malignant forms of tumour of the nature of sarcoma, because, when only partly removed, it grew again very rapidly. This view has, however, been shown to be wrong, for recurrence does not take place if the tumour is thoroughly removed, and metastases never occur. The growth appears as a rounded, pedunculated body, dark red in colour, and springing from the cartilaginous part of the septum ; it causes nasal obstruction and frequent attacks of epistaxis. The tumour is very vascular and is of the nature of a fibro-angioma. Occasionally the same type of tumour is met with on the lateral wall of the nose.

TREATMENT.—This consists in complete removal with a snare, and excision of a lozenge-shaped portion of the mucous membrane forming the base of the polypus.

Other forms of tumour, both simple and malignant, grow from the septum, but are very rare in that situation.

Osteoma may originate in the frontal sinus or in the ethmoidal region. It is usually of the hard ivory variety and removal by operation may present considerable difficulty.

Cysts.—These are more common than the foregoing and arise from two sources—(a) retention in the mucous glands in the floor of the nose, and (b) from the apices of the incisor teeth. Differential diagnosis is best made by an X-ray picture taken with the film in the mouth. The retention cyst of the floor of the nose, if small, may be dissected out through the anterior naris ; if large, the cyst wall may be dissected out through the buccal mucous membrane. When the cyst is dental

in origin, it must be attacked through the mucoperiosteum over the premaxilla.

The so-called cyst of the middle concha has already been mentioned (p. 17). An air-space in the middle concha is a developmental anomaly which may cause nasal obstruction and demand removal. Sometimes mucoid secretion accumulates in this space and it becomes purulent from infection. Treatment consists in removal of the greater portion of the concha which forms the wall of the cyst (*see Fig.* 20, p. 22).

Malignant Tumours.—Both carcinoma and sarcoma occur in the nasal cavities ; of the two, sarcoma is the more common. They are met with in young persons, and may arise as primary growths in the nose, or be secondary to growths beginning in one of the paranasal sinuses, especially the antrum. Carcinoma is met with as a rule in elderly individuals.

SYMPTOMS.—Nasal obstruction is one of the chief symptoms of malignant disease ; it varies in degree according to the size of the tumour, and may be complete. Another constant sign is nasal discharge, which is usually purulent, and may be associated with an extremely offensive odour. Epistaxis is a frequent symptom ; it may occur spontaneously, or may be induced by some slight manipulation within the nose. External deformity may be produced, an appearance which is very suggestive of malignancy, though it is sometimes found in cases of simple mucous polypi. A less common symptom is epiphora which is the result of blocking of the lacrimal duct. Pain is complained of, but glandular enlargement is not often observed.

APPEARANCES.—Sarcoma may spring from the septum, from the lateral wall of the nose, or from the antrum. Carcinoma generally grows from the lateral wall, but the exact point of origin can rarely be determined. Sarcoma may resemble mucous polypi, or may be associated with simple polypi. A reddish, sloughy-looking mass, very friable, and bleeding freely when touched, is suggestive of malignant disease.

DIAGNOSIS.—While the diagnosis of malignancy may frequently be suggested by the clinical features just described, microscopical examination of a portion of the tumour should always be made when there is the slightest doubt. If the diagnosis is confirmed, it becomes important to determine the exact extent of the disease, and for this purpose a radiograph gives satisfactory information.

TREATMENT.—Operative excision, combined with the use of diathermy, offers the best prospect of cure. Treatment with radium or X rays may follow, but radiological treatment alone appears to be rarely successful (Norman Patterson). Complete excision of the upper jaw is an obsolete operation ; in suitable cases the tumour may be approached through the mouth or nose, without external incision. The paranasal incision of Moure gives the best access to growths of the ethmoid. All dissection, with the exception of skin incision, is performed with the diathermy knife, and before the wound is closed the raw surface is treated with the diathermy button. Even when complete excision is not possible diathermy may afford relief, and this may be combined with the implantation of radium needles.

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CHAPTER VII

CHRONIC INFECTIVE DISEASES.

SYPHILIS.

Inherited Syphilis may appear in the form of coryza (snuffles), beginning in the first three months of life. It is characterized by obstinate nasal discharge which tends to dry up and form crusts ; also the irritation of the secretion causes fissures to appear at the anterior nares. At a later stage, usually at puberty, but sometimes not until adult life, gummatous ulceration may destroy the tissues and lead to atrophy and

Fig. 42.—Stigmata of congenital syphilis. Hutchinson's teeth. Sunken bridge Corneal opacities.

scarring, so that the bridge of the nose is depressed and fœtid crusts form within the nasal cavity. The permanent teeth and the cornea show well-known defects (*Fig.* 42). In infants so affected, other evidence of the disease should be looked for and the family history must also be investigated.

Acquired Syphilis.—Primary infections of the nose are very rare. Secondary lesions, in the form of mucous patches, are met with in the nose, but less commonly than in the pharynx, and only slight symptoms are produced. In its tertiary manifestations, syphilis may occur in the nasal cavities, both in its hereditary and acquired forms. The septum is the part most commonly affected, but the lateral wall of the nose may

be involved. The stage of gummatous infiltration is rarely seen, for as a rule ulceration and destruction of tissue have taken place before the patient presents himself for examination. The gumma takes the form of an irregular mammillated infiltration, dark red in colour, attacking one or both sides of the septum. Usually the only symptom at this stage is nasal obstruction, but there may be severe pain in the nose, and head-ache, and the nose may be tender and swollen. When ulceration occurs, it is accompanied by a purulent discharge which tends to dry and form crusts ; these emit a horrible stench which may be detected at a distance of several feet from the patient. The odour is, however, different from that of ozæna. After the removal of the crusts by syringing the nose, or by the method described in the treatment of ozæna, the ravages of the disease can be studied. If the septum is affected, it will be found to be perforated, and the perforation usually involves the bony structures as well as the cartilaginous portion. The posterior edge of the vomer may also be found necrosed. If the process is still active, the edges of the perforation will be covered with granulations. The loss of tissue may be so extensive that there may be sinking of the bridge of the nose, and even ulceration and destruction of the external nose. The structures of the lateral wall of the nose may also be extensively ulcerated, and in part destroyed. The nasopharynx is not immune from attack, and ulceration may be found on its roof and in the neighbourhood of the Eustachian cushion.

DIAGNOSIS.—The diagnosis is not difficult as a rule, but syphilis must be distinguished from ozæna, tuberculosis, lupus and glanders. In ozæna the fœtor is quite different, and ulceration does not occur. Tuberculous ulceration of the nose is almost always secondary to some other tuberculous lesion, and it is not accompanied by fœtor. In lupus there is not the rapid loss of tissue found in syphilis, and there is usually the nodular infiltration characteristic of that disease. Glanders may resemble syphilis, but is a much rarer condition. In doubtful cases Wassermann's test should be employed.

TREATMENT.—If the patient is seen in the infiltration stage and there is the least doubt about the diagnosis, antisyphilitic treatment should be commenced at once while awaiting the result of the Wassermann test, because the syphilitic condition advances with great rapidity to ulceration and necrosis, with resulting deformity. Apart from the general treatment of syphilis, local remedies are required. The nose should be kept clean by frequent syringing with mild antiseptic solutions (*see* Appendix), and it may also be sprayed with a solution of peroxide of hydrogen (10 vol.), while all loose sequestra should be removed. When the internal con-dition is cured, the external deformities of the nose, especially the depression of the bridge, may be remedied by a plastic operation (p. 32).

TUBERCULOSIS.

Tuberculosis rarely affects the nose primarily, save in the form of lupus. When it occurs it takes the form of a tumour which may produce ulcera-tion and destruction of tissue ; it appears as a granular growth springing from the septum, and may be mistaken for sarcoma, but microscopical

examination will show the true nature of the swelling (granulation tissue with tuberculous giant cells). It is more common to find ulceration taking place ; and the septum is the part most frequently attacked, the cartilaginous portion being first affected. The ulceration is soon followed by perforation of the septum. The lateral wall of the nasal cavity may also be attacked.

SYMPTOMS.—These are slight. The ulceration is attended by nasal discharge, but pain is generally absent.

DIAGNOSIS.—The diagnosis has to be made from syphilis and lupus ; but the site of the perforation, which in tubercle affects the cartilage and in syphilis involves the bony structures as well, and also the evidence of syphilis or tuberculosis in other parts of the body, should make the diagnosis clear. If there is any doubt, Wassermann's test should be employed ; if this is positive, it points to the lesion being syphilitic, but if the result is negative, a histological examination should be made. The diagnosis from lupus will be considered later.

TREATMENT.—Unless there is extensive tuberculous infection in other parts of the body, an attempt should be made to remove the diseased tissues completely. In order to do this the ulcerated areas should be freely curetted ; the raw surface may then be cauterized with the galvano-cautery, or painted with trichloracetic acid. The latter application should be repeated twice or thrice weekly until cicatrization occurs, as there is a great tendency to recurrence. Diathermy may be employed for the removal of the infiltrated area. The nose should be kept clean by irrigation with the nasal douche. The advisability of tuberculin treatment may also be considered.

LUPUS.

In the nasal cavities, lupus is more commonly met with than tuberculosis. Young persons, especially females, are attacked, and the disease here, as in other parts of the body, is extremely chronic. It is often associated with some cutaneous lesion, and it is extremely probable that nasal lupus and lupus of the face have a common origin in the vestibule of the nose at the junction of skin and mucous membrane (*Plate II*, 3, p. 36). As in tuberculous infections, the septum is the part generally affected, but the inferior concha is not immune. The characteristic nodular infiltration is recognizable, and this may be followed by ulceration and loss of tissue. External deformity is sometimes met with, such as sinking in of the tip of the nose, while the alæ nasi and the mobile part of the septal cartilage may be eroded and finally destroyed.

DIAGNOSIS.—The diagnosis of lupus is not difficult as a rule. The very slow progress of the disease serves to distinguish it from syphilis, while the characteristic nodular appearance of the infiltration, and the presence in many cases of a skin lesion, will help to differentiate the condition from tuberculosis, although some authorities suggest that the distinction between tuberculosis and lupus should be abolished.

TREATMENT.—The local treatment is the most important, and must be thorough. The diseased parts should be curetted with a sharp spoon, and lactic acid, chromic acid, or the galvano-cautery should then be

applied to the raw area. Recently ionization and diathermy, especially the latter, are more frequently used, and with satisfactory results. Treatment by X rays or radium, if available, may be tried. Tuberculin may also be administered, and is occasionally of benefit. The general health of the patient must also be attended to. Pfannenstill, in 1910, suggested a method of treating tuberculous processes by causing nascent iodine to be given off within the diseased tissues. He found that if sodium iodide were taken internally, and ozone inhaled, iodine was given off in a nascent form when these two substances came in contact. To obtain a satisfactory result, the diseased process must be localized, and there must be an ulcerated area. The method has been most successful when applied to cases of lupus of the nose, and a modified technique has been elaborated by Strandberg. The patient receives at first 1 grm. a day of sodium iodide, divided into six doses ; the amount is rapidly increased until 6 grm. are given every day. When the daily dose has reached 3 grm., gauze tampons are inserted in the nose twice daily, and moistened every ten minutes with a solution of peroxide of hydrogen. The patient is provided with a bottle of this solution and a pipette, and makes the application himself. At first there is a considerable reaction, and a weaker solution is then used. The treatment lasts two or three months. Out of 90 cases treated by Strandberg, 46 were cured. When, however, the lesion is so situated that it can be entirely removed with a sharp spoon followed by the local application of acid nitrate of mercury, this method will have both a more rapid and a more certain effect. For the successful treatment of lupus it is necessary to impress upon the patient the need of frequent re-examination.

ULCERATIVE GRANULOMA.

Under this heading is included a progressive and fatal disease of unknown origin, usually termed malignant granuloma, although it is not a tumour but rather a chronic inflammatory lesion.

The clinical picture is one of progressive destruction of the nose, face and pharynx, with prolonged fever and frequent hæmorrhages (J. P. Stewart).

The disease is practically confined to adult males, and must be differentiated, firstly, from syphilis, tuberculosis and malignant disease, and, secondly, from various affections of the tropics such as yaws, mycotic infection, gangosa, leprosy and oriental sore. Local treatment is of little or no avail, but deep radiotherapy appears to deserve further trial.

RHINOSCLEROMA.

This disease deserves a passing mention on account of its increasing incidence in Eastern Europe, although it has not been reported in this country. It consists of a hard infiltration of the mucous membranes of the upper air passages, with a secondary invasion of the lips and nostrils, which causes great disfigurement. In the nose it gives rise to obstruction and discharge, and a slowly progressive, though usually painless, stenosis. Treatment can only give temporary relief.

CHAPTER VIII.

EPISTAXIS, FOREIGN BODIES, AND PARASITES.

EPISTAXIS.

BLEEDING from the nose is a symptom of a large number of widely diverse conditions. In children it is a common symptom of adenoid vegetations. It is met with in diseases of the heart, the liver, and the kidneys ; on account of the latter, the importance of testing the urine should not be overlooked. It may occur in acute fevers, such as enteric, scarlet fever, measles, diphtheria and influenza ; and it is also found in diseases of the blood, including scurvy, purpura and hæmophilia. In many cases it is due to purely local causes. It may proceed from new growths (especially malignant) in the nose and nasopharynx ; it may occur in plethoric individuals ; it is more rarely vicarious, replacing the menstrual flow ; and it is frequently the result of injury. Brown Kelly has described a form of epistaxis which arises high up in the nose. Bleeding takes place from the anterior ethmoidal veins. The blood may escape in drops, or it may pour out so profusely that several pints are rapidly lost. If the blood is escaping only in drops, it will probably cease to flow spontaneously, and treatment will be unnecessary ; but where the hæmorrhage is free, it is the duty of the surgeon to endeavour to arrest it. If the bleeding has been at all abundant, the nose will probably be full of clots, and it will be impossible to locate the bleeding point—a very desirable preliminary to treatment. The nose should, accordingly, first be washed out with warm boric, or other mild antiseptic lotion, and should then be carefully inspected. If the blood flows too quickly to enable the bleeding point to be seen, a gauze plug saturated with a solution of peroxide of hydrogen (10 vol.) should be inserted ; this should be quickly withdrawn and the nose rapidly inspected.

The most common site for hæmorrhage is Little's area, or an area on the lower and anterior part of the cartilaginous portion of the septum (*Plate II.* 6, p. 36). If the bleeding is not coming from that region, the floor of the nose and the conchæ should be inspected. Tilley has reported an unusual case in which the bleeding area occurred on the septum behind a vertical ridge producing a deviation. The bleeding spot was found with much difficulty. Bleeding coming from the anterior area of the cavity can generally be stopped by anterior plugging. For this purpose strips of gauze, wrung out of a solution of peroxide of hydrogen (10 vol.), are most suitable ; the plugs may be left in for forty-eight hours. The Cooper-Rose tampon, a thin rubber bag, which is introduced

into the nose and then inflated, provides a painless and effective method of controlling epistaxis in many cases. If the hæmorrhage is not controlled by this means, plugging of the posterior nares may be resorted to, but this procedure is necessary only in the rarest instances, and it may be stated that, where careful anterior plugging has been of no avail, posterior plugging rarely has a satisfactory result. This is usually the case in blood diseases, as in hæmophilia, purpura hæmorrhagica, etc. Recently some success has been obtained by packing the anterior nares followed by intramuscular injection of hæmoplastin. In the cases of habitual nose-bleeding, it is very important to find the bleeding point which, in the great majority of cases, as has already been stated, is found low down on the anterior part of the septum. When detected, the area should be cauterized, either with a bead of fused chromic acid or with a flat burner heated to a dull-red heat; in using the latter the affected area is stroked with the burner while the current is being allowed to pass.

It occasionally happens that in habitual nose-bleeding the lower and anterior part of the septum is seen to be dry, and shows a tendency to collect inspissated mucus. In such cases the bleeding is often prevented by keeping this area lubricated with vaseline or liquid paraffin, applied either with the finger or an oil atomizer. Epistaxis due to foreign bodies, maggots, or leeches usually ceases after their removal.

FOREIGN BODIES.

Children sometimes introduce buttons, peas, beans, or similar bodies into the nose. If this is found out at once, the foreign body may be readily detected and removed ; but if left in the nose, a discharge is set up, which soon becomes purulent and fœtid. Accordingly, if a child is brought with a history of a unilateral discharge from the nose, it should at once raise the suspicion of a foreign body, even if no history of one can be obtained. If the object is one which swells with moisture, nasal obstruction may also be produced. The body may not be visible on inspection, owing to the swelling of the mucosa and the presence of pus. In such cases the nose should be cocainized, after which procedure a second inspection must be made, when the foreign body will probably be seen, or (if not seen) may be detected by the probe. When located, the body can generally be removed with ease by a pair of toothed forceps, or by a hook which is passed beyond the object and then withdrawn. If it is situated far back, it may be easier to push it on into the naso-pharynx. When dealing with children, it is frequently necessary to employ a general anæsthetic.

The association between nasal diphtheria and a foreign body is very common, and the removal of the foreign body cures the nasal discharge and incidentally the diphtheria (J. A. Keen). The Klebs-Löffler bacilli, or organisms which resemble them, are implanted as a secondary infection of the ulcerated area caused by the foreign body and are not primarily the cause of the symptoms.

RHINOLITHS.

Rhinoliths are calcareous masses which are occasionally found in the nose. The deposit of salts, chiefly carbonate and phosphate of lime, takes place round a nucleus, which may be a foreign body or merely blood or mucus.

SYMPTOMS.—These are the same as in the case of a foreign body, and the diagnosis may be made by inspection, or if necessary by the use of a probe.

TREATMENT.—This will be the same as for foreign bodies, namely, removal. If the rhinolith is too large to remove as a whole, it may be crushed with a strong pair of dressing-forceps, and extracted in pieces.

FUNGI AND PARASITES IN THE NOSE.

Aspergillus infections of the nose are not so rare as text-books would have us believe (Brown Kelly). The symptoms are sneezing, rhinorrhœa, and headache, and the most important sign is the discharge of pieces of tough greenish membrane which may coexist with polypi and granulation tissue. Treatment consists in thorough removal of all the fungus.

Rhinosporidium Seeberi causes a rare parasitic affection which has been observed mainly amongst the natives of Southern India, though its distribution is not limited to that area. The nasal polypi which are formed contain the spores in all stages of development. Clinically, the masses present the appearance of slender filiform or narrow leaf-like processes of a dull-pink or reddish tint, with the surface studded with many minute pale spots, due to the presence of the sporangia in the tissue. The growths are very friable and bleed readily when touched (Ashworth and Logan Turner). Treatment consists in the surgical removal of the infected areas. The local application of 2 per cent aqueous solution of tartarated antimony has been advised.

MAGGOTS IN THE NOSE (MYIASIS OR PEENASH).

In hot climates flies may deposit their ova in the nose and maggots result. It is rare for this to occur in a healthy nose ; it is more common in patients suffering from ozæna or nasal syphilis. Epistaxis, headache, lacrimation and sneezing develop, and are soon followed by a bloody discharge which becomes purulent ; ulceration and destruction of the nasal structures may occur ; death may result from meningitis.

TREATMENT, which is fortunately efficacious, consists in spraying or instilling oil, or chloroform and water, into the nasal cavities ; by these means the larvæ are irritated and crawl out of the nose. Care should be taken not to kill them *in situ*, as they remain a source of secondary septic infection.

CHAPTER IX.

ALLERGY AND ALLIED CONDITIONS.

UNDER the above heading are included the disorders which were formerly classed as nasal neuroses. The only true nasal neuroses are the disturbances of olfaction to which reference has been already made in Chapter II, p. 28.

Allergy may be defined as " a state of exaggerated susceptibility to various foreign substances and physical agents that are harmless to the great majority of normal individuals " (Bray). Many of the " allergic reactogens," but not all, are of protein nature. The recognition of nasal manifestations of allergy is of great importance. Neglect of the allergic factor accounts for many failures in nasal surgery.

The varieties of allergy which chiefly concern us here are : (1) Nasal allergy or vasomotor rhinitis ; (2) Pollen allergy of hay fever ; and (3) Bronchial allergy or asthma.

NASAL ALLERGY (Vasomotor Rhinitis).

Nasal allergy (vasomotor rhinitis), also known as allergic coryza or paroxysmal rhinorrhœa, most commonly affects women in the second or third decade of life and, unlike hay fever, it may occur at any time of year. The etiological factors may be climatic, as from sudden exposure to cold, or occupational, as in bakers, rubber workers, housewives, who are naturally subjected to inhalation of vapours or dust. Food may be responsible; for example, chocolate, tomatoes, eggs, etc., also emanations from dogs, horses, or other animals. Nasal allergy is often associated with asthma.

THE SYMPTOMS consist in sudden attacks of sneezing, with watery discharge from the nose and sensation of nasal obstruction.

Repeated sneezing may continue almost to the point of exhaustion. During the attacks the inferior conchæ are large, pale, and sodden in appearance, and the mucosa pits on pressure with a probe. A nasal smear may show numerous eosinophil cells.

TREATMENT.—In all cases a careful investigation of the environment and habits of the patient should be made, with a view to discovering the determining factor. If a specific irritant can be discovered from the history, or from reaction to skin tests with various allergens, then desensitization offers good prospects of cure. Outfits for testing may be procured, although the procedure is lengthy and costly on account of the great number of reagents required. Desensitization by non-specific

allergens such as peptone, milk, blood serum, and vaccines is also practised. As regards local treatment, Francis advised the cauterization of any hypersensitive spots on the septum, Hurst recommended the nasal inhalation of pure carbon dioxide gas in small amounts, and recently Franklin has reported good results from zinc ionization. Nasal sprays containing ephedrine and adrenalin are also useful.

Pollen Allergy (Hay Fever) is a distressing condition in which the patient is hypersensitive to the pollen of certain plants, trees, and grasses, the last mentioned being the most important. The symptoms are those of nasal allergy, but the sneezing and rhinorrhœa are accompanied by burning or itching sensations of the nose and of the conjunctivæ, and there is a definite seasonal incidence, in late spring or summer, when the pollen is present in the air. About one-half of the cases also suffer from asthma, and the patient is often completely prostrated.

TREATMENT.—This should follow the lines already suggested for nasal allergy. When the patient can afford it he may escape by taking a sea voyage or by living at a high altitude during the season. Attempts to exclude the pollen by air-filters in rooms, or masks for the patient's use, have only been partly successful. Although it involves time and expense, inoculation by an extract of the specific pollen, previously determined by a series of tests, offers the best means of securing desensitization. Wherever possible the time chosen for the course of injections should be just before the pollen season. Although stock solutions have been employed, prepared from timothy grass or from a variety of grasses, the results are inferior to those obtained by using pollen allergens to which the patient definitely reacts. As additional treatment the internal use of ephedrine sulphate gr. $\frac{1}{2}$ or of acid hydrochlor. dil. (B.P.) has been advised, while local symptoms are relieved by a nasal spray or ointment containing ephedrine or adrenalin chloride and by the use of dark glasses. Zinc ionization and nasal inhalation of carbon dioxide are also worthy of trial.

ASTHMA AND THE NOSE.

Asthma, or bronchial allergy, consisting essentially in dyspnœa, due to spasmodic contraction of the bronchial muscle, is the most important of the allergic diseases, but only the nasal factor need be considered here. Although the existence of an 'asthmagenic' area in the ethmoid region of the nose has been clearly demonstrated, both clinically and by animal experiments, and although nasal abnormalities are common in cases of asthma, it is well to remember the dictum of P. Watson-Williams that " the existence of nasal abnormalities in an asthmatic patient does not imply that they are causal factors ".

·The commonest pathological changes are nasal polypi, and infection of the paranasal sinuses. Polypi are so common in allergic conditions that some authorities state that all patients suffering from nasal polypi have a history of allergy. Infection of the nasal sinuses may be secondary to a series of allergic swellings of the mucous membrane. The ostia are closed, and the sinuses become favourable areas for bacterial growth.

Any form of nasal obstruction, by favouring mouth breathing, results in the entrance into the bronchi of cold and impurified air, and this naturally increases the asthmatic symptoms. While the nose of every asthmatic patient should be examined, and while it is advisable to deal with infection or with gross abnormalities, he would be a rash surgeon who would predict an invariably good result as far as the asthma is concerned.

ALLERGY AND NASAL OPERATIONS.

We have already sounded a warning regarding a too confident prediction as to the outcome of surgical treatment of the nose in asthmatic subjects. But it is important to determine in all nasal cases demanding operation whether there may not be some underlying allergic cause of the symptoms. Resection of a deviated nasal septum or removal of nasal polypi may prove disappointing if the basic allergy is neglected. The removal of tonsils and adenoids from a child suffering from allergic respiratory symptoms may not only be futile but may actually aggravate the trouble. In general, nasal surgery should be avoided in allergic patients. Even in sinus infection, when operation appears to be indicated, the treatment of the allergy may yield surprisingly good results. In any case operative measures should be conservative and should aim at ensuring nasal drainage and producing a free airway. Above all, the galvano-cautery should be used sparingly, if at all, in allergy.

CEREBROSPINAL RHINORRHŒA.

Cerebrospinal rhinorrhœa may be mentioned in this chapter, by reason of the symptom, although it has no etiological relationship with the diseases above mentioned. It is a rare disease, and as the name implies, it consists of a persistent discharge of cerebrospinal fluid from the nose, as a rule from one nostril only. The fluid does not stiffen linen on drying, is free from albumin and mucus and reduces Fehling's solution. Prognosis is usually unfavourable. The exact cause is as yet uncertain, and intranasal treatment should be avoided owing to the risk of meningitis.

TREATMENT.—There is no treatment. The condition sometimes ceases spontaneously and operative interference intranasally is to be avoided in such a case.

Section II.

AFFECTIONS OF THE PARANASAL SINUSES (ACCESSORY SINUSES).

G. EWART MARTIN and CHARLES E. SCOTT.

CHAPTER X.

INTRODUCTION. PATHOLOGY. ACUTE INFLAMMATION IN THE SINUSES.

INTRODUCTION.

THE paranasal sinuses constitute a group of air-containing cavities which communicate with the nasal chambers (*see* Anatomy, p. 6). They play a considerable part in the surgery of the face and head, being prone to infection by micro-organisms ; and from their close proximity to the brain and its membranes they are sometimes the primary source of intracranial infection. Similarly they may infect the tissues of the orbit with the formation of orbital abscess and, occasionally, they are responsible for ocular changes with resulting impairment of vision.

Suppuration in one or more of the air-sinuses is a common cause of recurring attacks of facial erysipelas. Inflammatory conditions of the pharynx, larynx and bronchi may be induced and maintained by the irritation of the purulent secretion from the nasal and paranasal cavities ; while gastric disturbance producing symptoms of indigestion may fail to respond to treatment because the swallowing of septic discharge has not been recognized as a possible etiological factor.

During recent years attention has been directed to the air-sinuses as foci of focal infection, from which micro-organisms of low virulence, or their toxins, invade certain tissues of the body producing pathological changes associated with a variety of clinical manifestations which depend upon the area of the body secondarily infected. The absence of nasal discharge in some of these cases, or its non-purulent character when recognized, probably explains why the sinuses are sometimes not regarded as the primary foci of the systemic infection.

For many reasons, therefore, it is essential that the student and practitioner of medicine should have some knowledge not only of the anatomy of the paranasal air-cavities and their relation to neighbouring parts, but also of the clinical types of disease affecting them and of the

methods of diagnosis. These sinuses are also present in young children and the possibility of suppuration in the early years of life, especially in connection with the exanthemata, should not be overlooked.

In this connection it must be mentioned that most observers agree that it is not the non-suppurative but the purely hyperplastic type of infection that is associated with asthma and other allergic conditions.

INFLAMMATORY AFFECTIONS OF THE PARANASAL SINUSES.

Etiology.—Acute inflammation of the lining membrane of the sinuses is due, in most instances, to the extension of the infection from the nasal cavities ; but Killian has pointed out that in scarlet fever they may be infected through the blood-stream. Two or more, or even all the sinuses, may become simultaneously infected. Inflammation may occur during an attack of acute rhinitis or 'cold in the head', perhaps more often than is generally supposed. Acute inflammation, however, is a more frequent concomitant of the influenza epidemics ; it may complicate pneumonia and occur in the course of the acute specific fevers which prove a source of infection in children. Injuries to the facial bones, operations upon the nasal and post-nasal cavities, injudicious medication of the nose, bathing and diving, have been recorded as etiological factors. In the case of the maxillary sinus, dental disease and tooth extraction may be responsible. Nasal infection of this cavity, however, is more common. Finally, one sinus may infect another.

Considerable attention has been paid to the influence of a deficiency of vitamins in diet as a factor in predisposing the mucous membrane of the nasal and paranasal cavities to infection. Similarly, too, a number of observations have been made upon the structural changes in the lining membrane of these cavities, especially of the maxillary sinus, in anaphylactic patients. It is obvious that with an increase in our knowledge of the part played both by diet and allergy, our methods of treatment of the air-sinuses will require to be revised, more particularly in relation to prophylactic measures against infection.

Bacteriology.—The paranasal sinuses are probably sterile in normal conditions of health, as no micro-organisms have been found in them within a few hours of death. The healthy nasal and post-nasal cavities, on the other hand, contain micro-organisms, but in smaller numbers, in pure culture, of lower vigour and of little or no virulence as compared with those present in the inflammatory conditions (Lewis and Logan Turner). These authors, as the result of their study of the bacteriology of sinus inflammation, have come to the following conclusions :—

1. Pyogenic cocci are more often responsible than bacilli for sinus suppuration.

2. Four main types of cocci are commonly met with, viz., pneumococci, streptococci, staphylococci, and diplococci of the type of *Micrococcus catarrhalis*.

3. The following groups of bacilli not infrequently occur : (*a*) *B. coli* and its allies ; (*b*) Putrefactive bacteria such as *B. proteus* ; (*c*) A diphtheroid group ; (*d*) *B. influenzæ* ; (*e*) Dental organisms, *B. gangrenæ*

pulpæ and *B. necrodentalis* ; (*f*) An obligate anaerobic group containing *B. perfringens* and *B. ramosus*. The two latter groups occur usually in the maxillary sinus. Fœtor, so commonly present in antral suppuration, alike in recent and in chronic cases, in those of nasal as well as in those of dental origin, may be due to the growth of certain of the micro-organisms causing the suppuration, or to others concerned in the decomposition of the products of inflammation.

Tilley and Shattock, and more recently Brown Kelly, have reported the presence of fungus growth in the antrum and ethmoidal cells, demonstrating the mycelium of *Aspergillus niger*.

Pathology.—The inflammatory affections may be non-suppurative (catarrhal) and suppurative, and in both varieties the inflammation, while at first acute, may pass into a chronic stage. The difference between the catarrhal and suppurative forms is mainly one of degree, as the former may pass insensibly into the latter. The changes in the lining mucosa of the cavities and in the character of the discharge differ in the two varieties. J. S. Fraser, in his investigations into this subject, has drawn the following conclusions. Cases of simple catarrh are those with œdema of the submucosa, with slight alteration of the superficial epithelium, and with a moderate leucocytic infiltration of the submucous tissue. The discharge is of a somewhat mucoid, transparent character often appearing in the washings in the form of 'blobs'. Again, in the chronic catarrhal variety the mucous membrane may become greatly thickened and a polypoid condition may develop ; there may be little or, indeed, no mucous discharge passing from the sinus into the nose. In allergic conditions the epithelium of the sinuses may be thickened and hyperplastic with polypoidal degeneration, the periosteal layers showing a round-cell and connective-tissue proliferation, while the overlying layers show an œdema with an eosinophilic infiltration. In such cases bacterial invasion is a secondary process.

In the suppurative type the histological appearances vary. There may be little or no œdema, but considerable leucocytic infiltration, the epithelium being almost unchanged in some cases but with extensive metamorphosis or with entire disappearance in others. Again, the œdema and leucocytic infiltration are sometimes pronounced, with slight or extensive epithelial changes. The discharge is definitely purulent. Disease of the osseous walls is not a frequent concomitant of suppuration in the sinuses. When the infection is virulent, however, or when the ostium becomes blocked and drainage is interfered with, caries and destruction of one or more of the walls may occur and the infection passes beyond the boundaries of the affected sinus, involving the cheek, the orbit, or the cranial cavity. Necrosis may indicate a syphilitic infection.

ACUTE INFLAMMATION.

The affections which may give rise to acute inflammation in one or more of the sinuses have already been referred to. The symptoms vary in their severity and are influenced by two factors—the virulence of the infection and the partial or complete retention of the secretion within

the cavity, consequent upon the closure of the orifice of the sinus. The latter is due to the swelling of the lining mucosa and to the tumefaction of the adjacent nasal mucous membrane.

In the cases of *milder infection*, and in those in which drainage is not interfered with, the onset may escape detection and the symptoms may be very similar to those of the acute coryza which provokes it. For this reason the infection may remain unrecognized ; it may resolve or pass into the chronic stage. A feeling of fullness, of tension. or of slight aching is complained of in the area of the affected cavity, probably aggravated by such acts as stooping, straining, or coughing and, in the case of the maxillary and frontal sinuses, slight tenderness may be elicited on pressing upon the walls of these air-cavities.

In the *more severe type* the symptoms are aggravated ; the feeling of tension is replaced by acute pain, often of a distressing character. The whole of the anterior group of sinuses may be simultaneously infected. The patient may have constitutional symptoms along with an elevation of temperature. If *the maxillary sinus* is affected *and the ostium occluded*, swelling of the cheek with œdema of the lower eyelid has been observed due to the swollen mucosa ; great tenderness accompanies pressure on the facial wall of the sinus. There may be absence of nasal discharge. The appearances may simulate those of *acute periostitis* of the maxilla ; but a differential diagnosis can be made from the history, by a careful intranasal examination and by the use of the special methods of investigating the antrum to be described presently (p. 69). *Acute osteomyelitis of the maxilla* occurs occasionally in infants and, as the appearances resemble those of acute empyema of the antrum in adults, the condition has been erroneously diagnosed as such. In acute osteomyelitis, however, the infection which is probably of buccal origin causes an inflammation of the dental sac, followed by necrosis of bone and the discharge of pus into the nose and mouth. It must be noted that an infection of the maxillary sinus may give rise to no pain over that sinus but to a referred pain above the orbit, thus simulating an acute frontal sinusitis ; but the pain, however, is aperiodic.

In acute inflammation of the *frontal sinus*, the supra-orbital pain which accompanies it is often severe and may be associated with headache and ocular pain. In these cases the supra-orbital pain has a very definite periodic character which is pathognomonic of acute frontal sinus inflammation, and is of considerable assistance in differentiating the condition from neuralgia of the supra-orbital nerve. Commencing in the early part of the forenoon, the pain becomes progressively worse towards midday or one o'clock, subsiding gradually during the afternoon. At night the patient is free from pain and his sleep is not disturbed. During the exacerbation the sinus area may be exquisitely tender to the touch and its outline can be accurately defined upon the forehead by palpation. After subsidence of the diurnal acute stage, the tenderness on palpation disappears to a large extent. The conjunctiva may become injected and photophobia may be complained of. If the drainage is imperfect a slight œdema may be observed over the sinus with puffiness

of the corresponding upper eyelid, thus furnishing additional evidence of the deeper-seated inflammation.

Acute inflammation of the *ethmoidal cells* or *sphenoidal sinus* occurs as a separate clinical entity, but it is not common, and the ethmoidal cells, in whole or in part, may be affected in association with an acute condition of the frontal and maxillary sinuses. The symptoms resemble those of an aggravated form of nasal and nasopharyngeal inflammation, with frontal or vertical headache and with pain behind the eyes. When drainage is interfered with, orbital or ocular complications may develop.

Examination of the Nasal Cavities and Sinuses in Acute Inflammation.—While the symptoms and signs just enumerated are suggestive of acute inflammation of one or more of the sinuses, the attention should be directed to a closer physical examination. When the affection is unilateral, a comparative study of the appearance of the nasal mucous membrane on the two sides will be of assistance. On anterior rhinoscopy the mucosa will be found congested and the inferior concha swollen, so that further observation may be impossible without the preliminary application of a weak cocaine solution. Inspection of the region of the middle concha is essential. That structure may present a swollen and œdematous appearance and, for the same reason, the uncinate process may be rendered visible. Mucoid secretion or a streak of pus may be seen lateral to the middle concha or, on the other hand, discharge in the middle meatus may be absent. This may be due to blocking of the ostium of the affected sinus ; it is not uncommon, however, in acute catarrhal conditions, especially of the frontal sinus, to find an absence of secretion in this situation. Attention should also be directed to the olfactory cleft and the presence or absence of discharge in it should be noted. If the condition of the patient will permit, posterior rhinoscopy and nasopharyngoscopy should be attempted, with the view of obtaining additional or confirmatory evidence in the meatuses of the existence of a sinus affection.

Information as to the various special methods of investigating the different cavities such as is afforded by transillumination, X-rays, and exploration of the sinuses will be discussed under CHRONIC SUPPURATION (p. 69 et seq.).

TREATMENT OF ACUTE INFLAMMATION AND SUPPURATION.

In every case in which the diagnosis of acute inflammation is made, it is advisable to adopt measures to relieve the condition and to facilitate resolution, so as to prevent the occurrence of those secondary changes in the mucous membrane which may lead to the development of chronic suppuration. Treatment, therefore, should be directed primarily to establishing free drainage through the ostia by reducing the swelling of the nasal mucous membrane and, further, to the employment of such means as may be thought suitable to relieve the patient's discomfort or pain.

Certain measures may be adopted which are applicable to all the sinuses when acutely inflamed. The patient should be confined to bed

or to his room and not exposed to variations in temperature. The bowels should be opened, and aspirin, phenacetin or a diaphoretic mixture administered at intervals. Abstinence from smoking should be enjoined. Hot fomentations to the forehead or cheek are soothing.

Per-nasal inhalations of steam impregnated with menthol are useful, especially when given in the form of an alcoholic solution (10 to 20 per cent of menthol in alcohol—*see* Appendix). This diffuses more satisfactorily than when the menthol crystals are merely dissolved in hot water. A half to one teaspoonful of the alcoholic solution should be added to a pint of water in a two-pint jug, the water being at a temperature of 140° to 150° F., the inhalation to be continued for ten minutes and repeated twice or thrice daily. In addition to, or as a substitute for, menthol, the swelling of the nasal mucosa may be reduced by the application to the middle meatus of cotton-wool pledgets soaked in 5 or 10 per cent cocaine solution, with or without the addition of one or two drops of adrenalin solution (1–1000). An attempt may be made to attain the same object by the use of a 3 to 5 per cent cocaine spray. The disadvantages associated with the employment of cocaine and adrenalin on wool tampons are twofold ; the expert is required to ensure their correct application, while the subsequent reactionary swelling and the return of the 'waterlogged' state of the nasal mucosa tend to defeat the object in view. One application, however, may suffice to cause a free discharge from the sinus and give the necessary relief ; but the menthol treatment, if less powerful, has obvious advantages. Various proprietary preparations of ephedrine in oil are now available having a somewhat similar but more prolonged effect on the nasal mucosa. The oil tends to distribute the ephedrine over the surface, thus giving a reduction of the œdema over a greater area of the nasal mucosa.

The employment of the electric-light bath, introduced by Killian, has proved very useful in the early treatment of these cases, especially in acute inflammation of the frontal sinus and, in many cases, it has undoubtedly made operative procedures unnecessary during the acute stage. The bath (*Fig.* 43) may be given once or twice daily and, if possible, the first sitting should be carried out in the early morning before the onset of the severe pain which characterizes the acute frontal case. The duration of the séance should be from 30 to 40 minutes, the temperature of the bath rising gradually to 158° or 176° and then being allowed to fall to 104° F. The cutaneous vessels become dilated and profuse perspiration may break out on the face. After its use it is advisable to take precautionary measures against exposing the patient to chills. Short-wave diathermy is now being used in the treatment of acute sinusitis.

Treatment by suction has its advocates. A Politzer bag, fitted with an olivary-shaped nozzle and emptied of its air contents, is inserted into the nostril of the affected side. The anterior nares are closed by the surgeon's fingers and the patient is directed to swallow, the bag at the same time being allowed to expand rapidly. It is conceivable that by such means discharge may be withdrawn from the frontal sinus and from some of the anterior ethmoidal cells, but the value of its application

to the maxillary sinus is doubtful. A reliable suction pump may effect this in a more satisfactory manner.

While one or more of the above methods of treatment may be employed in acute inflammation of the sinuses and recovery follow their adoption in a number of instances, special operative procedures are found necessary in individual sinuses when such treatment fails, or when orbital or intracranial complications threaten the patient.

The Maxillary Sinus.—Although spontaneous cure of acute maxillary sinus suppuration does occur, the position of the ostium does not favour drainage ; operative measures not infrequently are necessary. Puncture through the lateral wall of the inferior meatus or through the membranous portion of the middle meatal wall should be employed with lavage of the sinus, the procedure being carried out with the same preparation as,
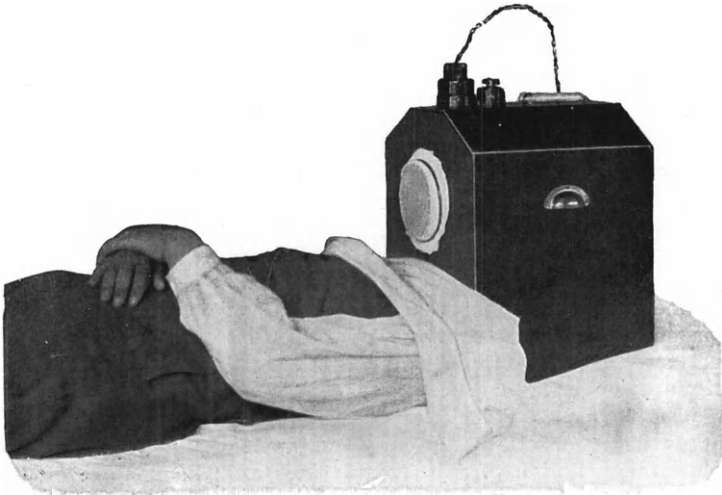
Fig. 43.—Head light bath.

and in a manner identical with, that described in regard to the exploration test (p. 73). In some cases one lavage suffices ; in others, it may be necessary to repeat the operation at close intervals. With care it is possible to pass the trocar through the same point in the bone on each occasion and thus to minimize the discomfort of the operation. It is very necessary, in these cases, to exclude the presence of a diseased tooth as a possible factor in maintaining suppuration and to deal with it ; otherwise lavage may prove a failure. Occasionally the swollen condition of the mucosa of the sinus round the ostium makes it impossible to evacuate the contents of the cavity by this simple procedure. In these circumstances a double cannula may be inserted to allow of better lavage and drainage. If repeated punctures fail to effect a cure an intranasal antral drainage may be necessary through a large opening in the inferior meatus. The old method of perforating the alveolus and inserting an obturator can only be deprecated.

The Frontal Sinus and Ethmoidal Cells.—If expectant treatment should fail to effect a cure, or in the event of the symptoms becoming aggravated, it is necessary to take steps to improve the drainage. In some cases the nasal septum, which may be markedly deflected to the diseased side, requires to be resected and straightened before any further intranasal operative measures are possible. Dislocation of the middle concha towards the middle line may afford freer aeration or drainage of the middle meatus. The attachment of the anterior end of the middle concha, the mucous membrane of which may be œdematous, should be divided high up on the lateral wall of the nasal cavity by the aid of turbinotomy scissors or by the employment of Sluder's knife ; the loop of a wire snare is then passed over the portion thus freed and the semi-detached end is removed. The removal with suitable punch forceps, those of Luc, Grünwald and Blakesley, of the anterior ethmoidal cells— frequently sharing in the inflammatory process—especially the cells of the agger nasi, is an additional necessary step in the establishment of better drainage and aeration of the frontal air-cavity. The patency of the ostium frontale can then be ascertained by the passage through it of a probe or a small-sized Watson-Williams' rasp without using the latter to enlarge the opening. If these procedures should fail to relieve acute symptoms, or if signs indicative of orbital or intracranial inflamma-tion supervene, an external operation on the sinus will be necessary (p. 88).

The Sphenoidal Sinus.—If the diagnosis of acute suppuration be made, it is necessary to remove the middle concha, to expose the anterior wall of the sinus and to establish drainage by enlarging the ostium (p. 91).

The administration of the appropriate autogenous vaccine or the corresponding antigen may be found useful in clearing up the discharge from any of the affected sinuses after drainage has been established.

Cases of acute sinusitis should be kept under observation until cure has been effected. If more strict attention were paid to this point, fewer cases of chronic disease of the sinuses would be encountered.

CHAPTER XI.

CHRONIC CATARRH AND SUPPURATION IN THE PARANASAL SINUSES : SYMPTOMATOLOGY AND DIAGNOSIS.

SYMPTOMATOLOGY.

UNDER this heading it is proposed to consider those cases of sinus disease which arise as a sequence of an acute inflammation which has failed to resolve. There must also be included, however, certain cases of maxillary sinus suppuration due to dental infection in which the preliminary acute stage was not present. One or more of the sinuses may be affected. The condition may be unilateral or bilateral. Unilateral nasal discharge in the adult should always raise a suspicion of the existence of suppuration in one or more of the sinuses.

The 'latent' character of the affection, in many cases, causes it to remain unsuspected, not only by the patient but by the physician. The ostium of the sinus remaining patent, the unimpeded evacuation of a small amount of discharge prevents the development of those acute phenomena which would inevitably direct attention to these cavities The affection may only be revealed in the course of an examination carried out to elucidate the origin of some complaint which may not have been attributed by the patient to any pathological change in the nasal cavities. Amongst such conditions may be mentioned rheumatic affections, indigestion, bronchial catarrh, neuralgia, headache, failure of bodily and mental vigour, and visual disturbance. On the other hand, the patient may be conscious of, and inconvenienced by, a persistent nasal or post-nasal discharge for which advice is sought. Sometimes the patient consults his doctor to seek advice for an offensive breath or intermittent bad taste. In these types of cases the nasal examination is incomplete without a careful investigation of the paranasal sinuses.

It is often difficult to determine the date of onset of *the nasal discharge* ; months or even years may have elapsed since the initial infection and the patient retains no recollection of the event ; or, when arising in connection with a diseased tooth, the origin may have been insidious from the first. Sometimes slight in amount and hardly noticeable, the discharge may again increase after each fresh cold. The secretion varies too, in appearance and consistence, being yellow and creamy when purulent, more transparent and tenacious when containing mucus. It has a tendency to crust-formation in posterior ethmoidal and sphenoidal sinus disease. The discharge is frequently fœtid when its source is in

the maxillary sinus, though even in these cases, as time elapses, the patient becomes no longer conscious of the odour. When a purulent nasal discharge has an odour perceptible to the patient, antral suppuration should be suspected. When the discharge takes the form of crusts, with the odour very obvious to others while the patient is unconscious of it, fœtid atrophic rhinitis will prove the probable explanation. Intermittency in the flow of pus, aggravated by the stooping posture, is suggestive of its antral origin ; at the same time, the diurnal periodic character of the discharge in cases of frontal and ethmoidal suppuration, more or less troublesome in the earlier hours of the day and decreasing in the later afternoon, has been a matter of observation. The passage of the secretion into the nasopharynx and throat, rather than towards the anterior nares, suggests its origin from the posterior group of sinuses ; but the existence of a large accessory maxillary ostium may favour the flow from that cavity in the same direction.

Nasal obstruction, varying in degree, may be an accompaniment of sinus suppuration, due either to the presence of nasal mucous polypi or to erectile swelling or œdema of the inferior concha.

Pain as a clinical phenomenon in chronic suppuration of the sinuses is a very variable symptom which may be absent throughout the whole course of this type of the affection. On the other hand, it may be complained of occasionally in the frontal sinus area, either due to a temporary defect in the drainage of that cavity, or, more commonly, in consequence of the pressure exerted by the œdematous condition of the middle concha upon the contiguous lateral nasal wall. Hence in chronic suppuration of the maxillary sinus pain may be referred to the area of the frontal sinus.

Headache, often an accompaniment of many nasal diseases, though also attributable to ocular defects, dental sepsis, or systemic disorders, may be diagnostic of sinus infection, though the pain may be referred to regions other than the affected sinus. The headache from an infected sphenoid may be supra-orbital and extend over the whole head and down the back of the neck; again it may be referred to the mastoid region or associated with a deep-seated pain behind the eyes. The headache of a frontal sinusitis is usually associated with severe pain over the affected sinus and accompanied with a feeling of weight over the forehead. These headaches are often purely morning headaches. The headache of a chronic suppuration of the maxillary antrum is also often referred to the frontal region ; it is intermittent and increased on stooping.

Giddiness and *tinnitus* are symptoms which may be associated with chronic suppuration in the sinuses.

DIAGNOSIS OF CHRONIC SUPPURATION IN THE ANTERIOR GROUP OF SINUSES.

(The Maxillary Sinus, Anterior Ethmoidal Cells and Frontal Sinus.)

A careful inspection of the nasal cavities should now be undertaken. Owing to the close anatomical relations of the different ostia and to the

fact that more than one sinus may be affected, an accurate diagnosis of the actual condition which is present may prove difficult and may only be obtained by a process of exclusion. Moreover, the nasal appearances vary from time to time, and signs of diagnostic importance which may be absent at one examination may be present at another. The sinuses of the anterior group, the maxillary, anterior ethmoidal and frontal sinuses, the ostia of which communicate with *the middle meatus*, should first be investigated.

ANTERIOR AND POSTERIOR RHINOSCOPY.—The inferior conchal body may present a swollen, turgescent appearance which to some extent may obstruct the view of the deeper parts of the nasal cavity. The application of a weak solution of cocaine (3 to 5 per cent) or an oily preparation of ephedrine will reduce the obstruction and thus render the examination more easy. The middle meatus is then inspected, and if pus is observed in this situation, the sinuses of the anterior group should be suspected as the probable source of the discharge. In the absence of pus, however, it must not be assumed that there is no further necessity for investigating these cavities. An œdematous condition of the mucosa covering the anterior end of the middle concha, or a similar appearance of the mucous membrane upon the uncinate process, should suggest the existence of discharge as a source of irritation responsible for the mucosal changes seen on these structures. These appearances must not be confused with the thin œdema of the structures in the upper part of the nose, although mostly on the septum, which is due to some allergic condition.

POSTERIOR RHINOSCOPY is then employed, and a favourable examination may disclose, in the middle meatus, a drop of pus upon the upper surface of the posterior end of the inferior concha—clinical evidence of considerable value when no secretion has been detected during the anterior examination. Discharge in the region of the auditory tube or on the upper surface of the soft palate on the suspected side is not without significance in this connection.

Diagnosis of Suppuration in the Maxillary Sinus.—As this cavity is frequently affected, and as its anatomical position renders it very easily accessible, it should be investigated in the first instance. When pus is secreted by the antrum and is visible in the middle meatus on anterior rhinoscopy, it occupies, as a rule, a position between the middle and inferior conchæ, further back and at a lower level than when it is derived from the frontal sinus (*Plate III*, 1, 2). This, however, is by no means conclusive evidence.

THE POSTURE TEST.—The middle meatus must be carefully cleansed, all traces of pus being removed by means of probes dressed with cotton-wool. The head is then bent forwards so that the vertex becomes dependent, while the cheek of the suspected side is turned uppermost. This position is maintained for four to five minutes ; a very brief employment of the test may defeat its object, which is to encourage the flow of the antral discharge towards the ostium situated in the upper part of the medial (nasal) wall of the sinus. With the head thus placed, the ostium occupies temporarily a dependent position. The reappearance

PLATE III

AFFECTIONS OF THE NASAL SINUSES

1. Pus in left middle meatus (maxillary sinus).

2. Pus in middle meatus (frontal sinus).

3. Pus in olfactory cleft (posterior air cells).
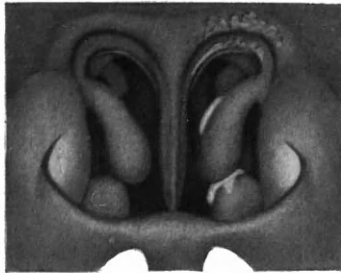
4. Pus in superior and middle meatuses and on superior choanal margin.
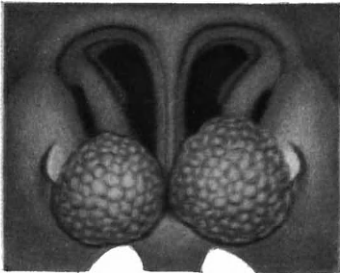
5. Enlarged posterior ends of inferior conchæ.
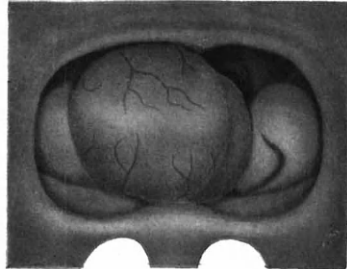
6. Choanal or naso-antral polypus (right side).

of pus in the middle meatus after posture is strongly presumptive of its escape from the maxillary sinus. A negative result, however, must not lead the examiner to make a wrong deduction, as a small quantity of pus may be present in the sinus and may fail to pass through the ostium when the head is lowered. Posterior rhinoscopy should also be employed after posturing, as, in cases with an accessory maxillary ostium, the discharge may drain backwards and be visible in the posterior part of the middle meatus. Occasionally, after stooping, the patient is conscious of a disagreeable odour, even when it is not possible to detect a discharge by rhinoscopy. This subjective sensation is a valuable diagnostic aid.

TRANSILLUMINATION TEST.—For this purpose a small 4- to 8-volt lamp affixed to a special tongue depressor is placed in the centre of the patient's mouth and the lips are closed firmly over the stem. Care is taken to have the room darkened, or to cover the heads of the patient and examiner with a photographer's black cloth. Before the introduction of the lamp the upper jaw denture, if one is worn, should be removed.

A rheostat should be attached to the apparatus supplying the electric current, so as to enable the examiner to increase the illuminating power of the lamp. It is advisable to commence the test with a weak illumination and gradually to increase the intensity, as in this way it is easier to detect differences in shade upon the two sides of the face than when the maximum illumination is used at the outset.

The test, introduced by Voltolini and elaborated by Heryng, is based on the fact that in many normal individuals the light rays are transmitted through the walls of the antrum, so that certain areas of luminosity become visible on the face. The passage of the rays through the roof of the cavity produces, in the majority of persons, a crescentic illuminated zone in the region of the lower eyelid (*Fig.* 44). It is this *crescentic tache* which must be specially considered in relation to diagnosis and not the illuminated areas frequently seen over the facial wall of the cavity in young and spare individuals and in those with large thin-walled antra. The inner third of the crescentic tache is the brightest portion of this illuminated area and it may be the only part which is lit up. Brown Kelly has shown that it is due to the passage of the rays through the lacrimal groove, and that its presence does not indicate illumination of the antrum. He has named it *the lacrimal tache*.

As the rays may also penetrate the coats of the eyeballs, the pupils may present to the observer a luminous glow (*Fig.* 44). Further, when carrying out the transillumination test, if the individual is directed to close the eyes, and the electric current is then switched rapidly off and on, he may receive a subjective impression of light in each eye (Brown Kelly). Transillumination, therefore, in many persons furnishes three signs : the crescentic tache, the bright pupil and the subjective light sensation.

The first must be regarded as the most useful, when the test is employed in the detection of disease, and it follows, as a matter of course, that its utility is greater when an infection of one antrum is suspected. The

presence of pus in the cavity, or of inflammatory changes in its lining mucosa, will interfere with the transmission of the light rays and thus diminish the luminosity of the crescentic tache or even cause its disappearance. The contrast with the normal side will thus assist in establishing the diagnosis of maxillary sinus suppuration. With suitable lamps of the filtered type, such as the Cameron Lamp, transillumination of the antrum may be carried out in the reversed direction. With the protected lamp placed at the outer margin of the orbit, the light illuminates the antrum on that side. The patient holds the mouth wide open and the transmitted light can be seen in the hard palate and

Fig. 44.—Transillumination of the maxillary sinuses.

on both sides of the alveolar margin under the antrum. A dull glow or complete absence of illumination may suggest an infected antrum, but a comparison of the two sides gives a better idea of the condition of the sinuses.

Various fallacies, however, may curtail the usefulness of the test. In normal subjects, asymmetry of the two cavities, unusual thickness of their osseous walls and a unilateral nasal obstruction, will interfere with the transmission of the rays of light. Again, disease may be present in one sinus and yet the same brilliancy of illumination may be obtained on the two sides, while both cavities may illuminate faintly, or not at all, and yet neither may be diseased. In young children before the completion of the primary dentition, the small size of the antrum, the surrounding cancellous bone and the unerupted teeth interfere with the transmission of the light rays. The value of transillumination has been variously estimated by different observers, some of whom attach no importance to it; but there can be no doubt that, if employed with a

due appreciation of the possible fallacies and in conjunction with the other clinical phenomena in the case, it furnishes considerable assistance in establishing the diagnosis of maxillary sinus suppuration.

THE X-RAY TEST.—A postero-anterior radiograph of the head will furnish additional information, especially in cases of unilateral disease when a comparison of the two sides can be made. Its employment is probably less necessary in cases of suspected antral mischief than it is in the investigation of the ethmoidal and frontal cavities, because in the former case other reliable diagnostic measures are at the examiner's disposal. When used, however, the fact should not be lost sight of that the radiograph has its limitations and is of value only in conjunction with the other clinical signs that may be present. Stereoscopic radiographs are of special benefit. The lateral radiograph of the head is of service prior to the carrying out of operative procedures upon the sinuses (*Plate IV*, C). Two antero-posterior positions are preferable—" chin–nose and nose–forehead ", while a vertical film will certainly help in the diagnosis of posterior ethmoidal and sphenoidal infections.

In order that this method of examination may prove most service-able a routine standardized technique should be adopted. Again, only a good plate should be deemed reliable ; preferably the film should be examined in a properly constructed view-box. In unilateral suppura-tion of the antrum the dark area representing the normal cavity is replaced by an opaque shadow varying in its density in different cases, but furnishing a contrast with the normal side (*Fig.* 45). In suspected bilateral disease it may be more difficult to estimate the value to be attached to the antral shadows. Occasionally, when the X-ray shadow suggests an affection of the cavity, exploratory puncture reveals no evidence of disease. Opinions differ as to the diagnostic value of pre-liminary filling of the cavity with radio-opaque iodized oil. Some regard this procedure as enhancing the value of the X-ray examination by making the pathological changes in the mucous membrane more evident ; others attach little or no importance to its employment.

The displacement method evolved by Proetz, as not only an aid to diagnosis but also as a form of treatment, is a useful modification of the usual sinus radiography. For diagnostic purposes a vacuum is created in the sinuses with a suitable syringe pump and the iodized oil allowed to enter by negative pressure. The resultant radiographs will reveal the sinus opaque, unless there is a closed ostium present, when the iodized oil will have failed to enter. Evacuation of the sinus also plays a part in diagnosis, Proetz stating that in seventy-two hours all the iodized oil should have disappeared unless the lining mucosa is chronically inflamed.

In children the radiograph plays a more useful part than does the ordinary transillumination method. Moreover, it gives valuable informa-tion as to the size of the cavity and the relation of its floor to the lateral wall of the inferior meatus—a point of importance when diagnostic puncture is contemplated

THE EXPLORATION TEST.—Transillumination and radiography with or without iodized oil are never entirely diagnostically conclusive. Proof

of maxillary sinus suppuration is obtained by exploration of the cavity either by washing it out or by aspirating its contents. It is not always necessary, however, to carry out the exploration test, as in a number of cases the diagnosis can be arrived at by collating the various clinical phenomena already referred to.

Exploration should be carried out by way of the nasal cavity, and not through a tooth socket. One of two alternative routes may be

Fig. 45.—Postero-anterior radiograph of the paranasal sinuses, demonstrating suppuration in the left frontal, ethmoidal, and maxillary sinuses. (The *negative* has been reproduced.)

adopted—(1) through the lateral wall of the inferior meatus, beneath the attachment of the inferior concha, or (2) through the membranous portion of the lateral wall of the middle meatus. The former is that more commonly employed ; but if, as occasionally is the case, the trocar fails to penetrate the bone, the middle meatal route may be substituted.

1. *Puncture through the Inferior Meatal Wall with Lavage of the Sinus.*—For this purpose a Higginson's syringe and a suitable trocar and cannula

PLATE IV

RADIOGRAPHS OF NORMAL PARANASAL SINUSES
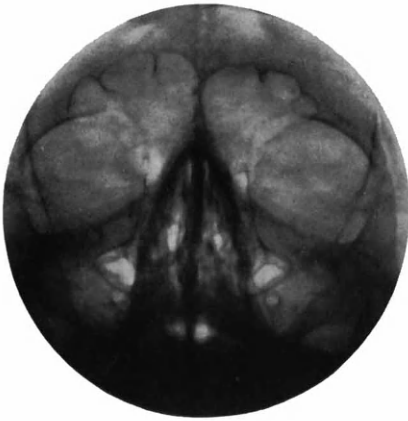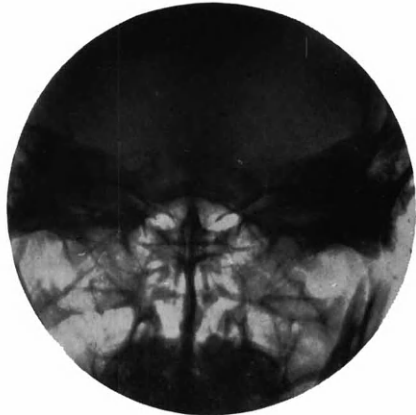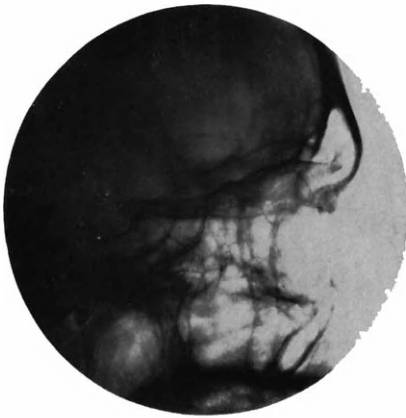
(A) Chin-nose position demonstrating the frontal sinuses ; (B) Forehead-nose position demonstrating maxillary and ethmoidal sinuses ; (C) Lateral view of the sinuses ; (D) Chin-vertical position demonstrating sphenoidal and ethmoidal sinuses.

are sterilized ; the straight pattern introduced by Brown Kelly, a modification of the Lichtwitz trocar, will be found very serviceable. The nasal cavities are first carefully cleansed so as to eliminate the source of error arising from the presence of pus in the nasal cavity ; otherwise the test will be falsified, as there is no guarantee that the discharge appearing in the lotion has actually come from the maxillary sinus. Under the guidance of reflected light, a pledget of cotton-wool, soaked in a 10 per cent cocaine solution and attached to a fine probe, is placed against the lateral wall of the inferior meatus, at least an inch within the vestibule; this is left in position for five to ten minutes. Another pledget, similarly treated, may be laid upon the anterior end of the inferior concha in order to reduce the turgescence, while a third probe may be introduced into the middle meatus to reduce any œdema of the ostium. A warm, sterilized saline or boracic solution is employed to wash out the cavity. After removal of the pledgets, the trocar and cannula are introduced under the inferior concha and directed obliquely backwards, upwards and laterally to a point just beneath the line of attachment of the inferior concha where the bone is usually thinnest (*Fig.* 46). The instrument is pressed through the osseous wall, the patient's head being steadied and kept horizontal. The trocar is then carefully withdrawn, the syringe is attached to the cannula and, with the head inclined over a basin, the lotion is gently injected ; it escapes from the sinus through the ostium to return by the nasal cavity to the basin, where it is carefully examined. It is often advantageous to receive the washings in a black bowl. If the trocar fails to penetrate the bone at the first attempt, a trial should be made at a point somewhat further back than that

Fig. 46.—Puncture of the right maxillary sinus through the lateral wall of the inferior meatus by a curved trocar.

at first selected. After a second failure, it is probably better to desist and to consider the feasibility of exploring through the middle meatus (p. 76).

Occasionally the injected lotion will not return through the ostium of the sinus. This may be due to the swollen, œdematous condition of the lining mucous membrane occluding the natural orifice. On the other hand, the cannula may have entered a dental cyst with an intact wall occupying the interior of the antrum. Accidents sometimes complicate this apparently simple operative procedure. Thus, when the cavity of the sinus is small owing to abnormal approximation of its facial and nasal walls, the trocar in perforating the lateral wall of the inferior meatus may pass anterior to the cavity into the soft tissues of the cheek (*Fig.* 14). This is recognized by the immediate swelling visible on the face and from the pain experienced by the patient. If aseptic precautions have been taken in carrying out the operation the accident is not attended by any troublesome sequelæ. Again, the floor

of the orbit has been accidentally punctured, the trocar having been pushed not only through the nasal wall of the antrum but also through its roof. Alarming symptoms and even fatalities have occurred associated with exploration of this sinus. They are rare, however, and have followed, as a rule, the attempt to blow the discharge from the cavity into the nose, instead of using the douche. Possibly the explanation of the symptoms is to be found in the production of an air-embolus. It is wiser to avoid the inflation of air. It is imperative not to use force at any time during this procedure, especially when the ostium is apparently blocked.

2. *Puncture through the Middle Meatus.*—By the use of a specially curved blunt-pointed cannula the membranous portion of the middle meatal wall may be pierced. The part selected is situated above the middle third of the inferior concha, and, as in the previous method, the area is anæsthetized with cocaine. The point of the cannula is passed along the superior edge of the inferior concha for a distance of two inches and is then pressed laterally and slightly downwards. The syringe is attached and the lotion introduced. The method is not always feasible, as the size and shape of either the middle or inferior concha may interfere with the access to the desired area.

The Suction Syringe.—As a substitute for the method of lavage, aspiration of the contents of the sinus is sometimes practised for diagnostic purposes. After puncture of the inferior meatal wall, a syringe containing a small quantity of distilled water is attached to the cannula ; this is quickly injected into the antrum and then sucked back, so that a sample of the contents is obtained. The method has the advantage that contamination of the lotion by passage through the nasal cavity is reduced to a minimum ; consequently the bacteriological examination of the fluid is of more value. The greatest care must be taken, by preliminary cleansing of the nasal vestibule and cavity, to prevent contamination of the point of the syringe. The parts may be mopped with a 50 per cent alcohol solution or with tincture of iodine. P. Watson-Williams has introduced a universal syringe with appropriate interchangeable ends suitable for similar exploration of all the sinuses.

As an alternative to this method is the use of a thin cannula attached to a 20-c.c. Record syringe. This cannula is of smaller calibre than the antral cannula and is passed through the latter. Distilled water is syringed into the antrum and sucked out. This method is of the greatest use when there is a blocked ostium, as owing to there being a slight leakage between the two cannulæ a vacuum cannot be created in the sinus, causing pain to the patient and preventing the collection of fluid. Antral puncture by this lavage method is carried out in the sitting position, while antral puncture with suction can be carried out either sitting up or lying down.

The character of the antral contents obtained by one or other of these methods varies in different cases. The presence in the washings of one or more blobs of mucus, perhaps slightly yellow-stained, indicates the catarrhal character of the inflammation ; shreds of purulent material may float in the lotion without changing in any degree the general clear

appearance of the fluid ; or the whole washing may be turbid and greenish in colour and give off a distinctly fœtid odour. In suspected cases, even when no change is observed in the lotion, P. Watson-Williams recommends the bacteriological examination of the aspirated fluid before deciding that the sinus is healthy. He regards this as the only method by which accurate differentiation can be made between the normal and the infected cavity. Tweedie suggests the use of both alkaline and acid media for culturing.

The diagnosis of chronic maxillary sinus suppuration may be briefly summarized from the foregoing account. Unilateral nasal discharge. not infrequently fœtid, and somewhat intermittent in its incidence and affected by posture, is presumptive evidence. The presence of pus in the middle meatus, reappearing or increasing in amount after stooping, combined with opacity on transillumination and with the cavity shadowed in the radiograph, makes the diagnosis extremely probable ; while the removal of secretion by syringing or aspiration and the detection of micro-organisms make this certain.

Diagnosis of Suppuration in the Frontal Sinus.—Although in many cases the antrum is the only sinus affected, the examiner, having satisfied himself as to its diseased or healthy condition, should turn his attention to the possibility of an affection of the frontal sinus or anterior ethmoidal cells. The employment of radiography has done much to simplify this aspect of the subject, and if an X-ray plate has been examined in connection with the investigation of the antrum, some information as to the condition of the other sinuses has already been obtained.

If, on antral lavage, the secretion has been found scanty, while the nasal discharge complained of by the patient and evident on nasal examination is considerable in amount, suspicion of further mischief should be aroused. After the maxillary sinus has been douched, the middle meatus should be cleansed of all traces of pus and the patient directed to maintain his head in the erect posture for five or ten minutes. The reappearance of discharge high up in the cleft between the middle concha and lateral nasal wall is presumptive of its origin from the frontal air sinus (*Plate III*, 2, p. 70). A repetition of this test with a positive result will only increase the suspicion, and if the discharge is combined with tenderness on pressure upon the thin bony floor of the frontal sinus, the presumption that that cavity is affected will be strengthened.

TRANSILLUMINATION TEST.—Since the introduction of the X rays, this test has been largely discarded in favour of the radiograph. It is possible, however, to delimit the vertical area of the frontal sinus in a number of heads by using the lamp employed in the examination of the maxillary sinus. When covered by a shield with a terminal opening, it is placed against the floor of the cavity beneath the medial third of the supra-orbital margin. Should the sinus area fail to illuminate, no definite decision can be made as to whether the opacity is due to disease, to the thickness of the sinus walls, or to the absence of the cavity.

THE X-RAY TEST gives more valuable information. and a radiograph should always be obtained when the frontal sinus is under consideration :

it may not only assist the diagnosis but furnish useful anatomical information if operation is contemplated. While both lateral and postero-anterior views of the head are desirable for therapeutic purposes, the latter is essential for diagnosis. An indifferent film should be discarded. When the sinus is diseased, the sharpness of its contour is lost, becoming blurred and ill-defined, while the shadow presented by the general surface of the cavity is opaque in the film, contrasting with the better definition and the darker area in health (*Fig.* 45). If the disease is unilateral, the contrast between the appearances on the two sides is of great diagnostic assistance. In cases of bilateral disease it may be more diffi-cult to reach a decision ; then the blurring of the outlines becomes the more important factor in diagnosis. When the sinuses are small and shallow, the difficulty of interpretation is increased, especially when both cavities are affected, because in the normal, small shallow sinus the edges are not so well defined and the shadow which it casts is not so dark as in the deeper cavities. The presence or absence of a sinus, however, is usually ascertained by the study of the pos-tero-anterior radiograph.
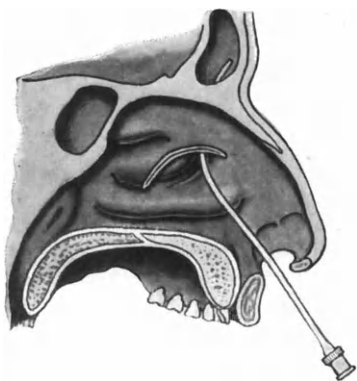
Fig. 47. — Catheterization of the frontal sinus after removal of the anterior portion of the middle concha.

CATHETERIZATION OF THE SINUS (*Fig.* 47).—While the information obtained up to this point has made the diagnosis of frontal sinus sup-puration very probable, more precise knowledge may be derived by pas-sing a probe or the frontal cannula through the ostium of the cavity. These instruments should be pliable, as it may be necessary to vary the terminal curve to suit the anatomical variations of the passage in different cases ; they should also be graduated in centimetres. The ostium frontale is situated 6 to 7 cm. from the an-terior naris. The position of the point of the instrument within the sinus may be gauged from the centimetre scale, or a rough estimate may be made by first placing the probe externally on the face and noting the distance from the lower edge of the vestibule to the eyebrow.

The middle meatus is cleansed and cocainized and the probe is in-troduced under the guidance of the eye. On its withdrawal, pus may be seen to enter the meatus. If a cannula is substituted, a rubber bag is then attached to its proximal end and the sinus is inflated under inspection. Secretion may be blown into the meatus. Experience is required in carrying out the test, and there is a possibility that in some cases the cannula does not enter the frontal sinus but passes into a high-placed anterior ethmoidal cell. It may be advisable to repeat the procedure on another occasion ; preferably a morning hour should be selected, as the mucous membrane of the frontal sinus appears to secrete less actively in the later hours of the day.

The diagnosis of frontal sinus suppuration may be summed up as follows : After determining, in the first place, the condition of the antrum, and washing it out if affected, the reappearance of pus in the middle meatus with the head maintained in the erect posture, associated with tenderness on pressure upon the floor of the cavity, furnishes presumptive evidence of disease ; the distinctive shadow in the sinus-area and the blurring of the outline in the radiograph make the diagnosis extremely probable. Finally, if the cannula can be accurately passed into the sinus and pus blown or washed out, the diagnosis can be established with more or less certainty.

Diagnosis of Suppuration in the Anterior Ethmoidal Cells.—Situated in an intermediate position between the frontal and maxillary sinuses, these cells frequently participate in the chronic suppurative process. On the other hand, suppuration may be confined to the ethmoidal labyrinth, involving either individual cells or both the anterior and posterior groups. The diagnosis will be made largely by a process of exclusion after the condition of the two larger cavities has been ascertained by the methods just described.

Among the symptoms of chronic suppuration already enumerated, those which are referable to the higher brain centres are probably more pronounced in ethmoidal disease. Thus, mental depression, inability to concentrate on work, and even impairment of memory may be complained of. Loss of smell is frequently associated with the condition and the degree of nasal obstruction is probably greater. When these symptoms are associated with a more or less constant discharge of pus, all of which cannot be traced to the antrum or frontal sinus, there is strong presumptive evidence of ethmoidal disease.

Inspection of the nasal cavity by anterior rhinoscopy may reveal the presence of pus in the middle meatus, possibly associated with a similar discharge in the olfactory sulcus, if the posterior cells are also affected. In many cases, however, nasal polypi obscure the anatomical picture, the association of pus and polypi being very significant of chronic ethmoidal suppuration. The combination of pus and polypi is found more frequently in connection with these cells than in either chronic maxillary or frontal sinus suppuration. The pink or reddish appearance of the polypi, in contradistinction to the greyish or more opalescent character of the polypi in non-suppurative cases, is also suggestive of the suppurative type of ethmoiditis. The insertion of the nasal probe, either naked or dressed with cotton-wool, may be followed on withdrawal by an increased flow of secretion.

A good radiograph, either a postero-anterior or vertical view, is of undoubted value in these cases, even when the condition is bilateral, as the opacity thrown by the diseased ethmoidal cells offers a distinct contrast to that usually recognized as distinctive of the normal condition of the cells. This evidence, in association with the nasal appearances described above, makes the diagnosis very probable.

If the polypi be removed along with the middle concha and a subsequent examination of the nose is undertaken, the pus can be more definitely located, and by cleansing, by observation and even by removal of portions of the cell walls, the source of the discharge can thus be made certain.

DIAGNOSIS OF CHRONIC SUPPURATION IN THE POSTERIOR GROUP OF SINUSES.

Posterior Ethmoidal Cells and Sphenoidal Sinus.—Up to this point the investigation has been conducted with the object of tracing the source of the pus observed in the middle meatus. Attention must now be directed to the study of those cases of suppuration in which, on anterior rhinoscopy, pus is seen in *the olfactory sulcus* between the middle concha and the septum and, on posterior rhinoscopy, in the superior meatus.

The sinuses of the posterior group, with their ostia communicating with the superior meatus and the spheno-ethmoidal recess, may be involved in conjunction with those of the anterior group, or the suppuration may be limited to the posterior cavities which very frequently, though not in every instance, are affected in combination. The process of diagnosis by exclusion must therefore be continued. The close proximity of the posterior ethmoidal cells to the sphenoidal sinus and the similarity both in the symptoms and in the nasal appearances which may be caused by suppuration, although making a differential diagnosis difficult in some cases, necessitate the consideration of the cells and sinus together.

Certain subjective symptoms dependent upon the anatomical position of the cavities may suggest the nature of the affection. Thus, an accumulation of secretion in the back of the nose and throat, associated with a desire to clear the passages by drawing it back and hawking, is complained of. There is a tendency, too, for the discharge from this source to dry and to form crusts which adhere to the mucosa of the posterior nares and to the vault and posterior wall of the nasopharynx. A disagreeable odour may be observed, but on the other hand, owing to anosmia, this symptom may be in abeyance. Pain of a neuralgic character and periodic in its development is complained of in certain of these cases. While attempts have been made in sphenoidal sinus disease to attach diagnostic significance to the localization of the pain in the occipital and temporal regions—sometimes referred to one ear— or on the vertex of the skull, such localization may prove misleading. The intimate association of the posterior sinuses with the optic nerve, the oculomotor nerves and the maxillary division of the trigeminus, may lead to visual disturbances, ocular paralysis and neuralgia, which should direct attention to the possibility of a causative factor within the nose. While the above phenomena may furnish presumptive evidence of the existence of disease in the posterior cavities, it must be borne in mind that, owing to the very latent character of some of these cases, they remain unsuspected both by the patient and his physician.

Nasal examination may reveal the presence of pus in the olfactory sulcus, sometimes associated with œdema of the middle concha and with a corresponding swelling of the tubercle of the septum (*Plate III*, 3, p. 70). On the other hand, anterior rhinoscopy may fail to reveal evidence of discharge. In the absence of pus, a probe dressed with cotton-wool may be introduced into the cleft and, on its withdrawal, be found coated with discharge. Posterior rhinoscopy will often give valuable information, the position of the sinuses favouring the backward flow of their

contents. Pus in the superior meatus upon the upper surface of the middle concha, or adhering to the superior margin of the corresponding choana and to the nasopharyngeal vault and posterior wall, is a significant sign (*Plate III*, 4, p. 70). The tendency of the discharge to dry and form crusts is more often seen in sphenoidal suppuration. This is due to the comparatively small quantity of the discharge which is secreted by that cavity. A reddish, succulent appearance of the nasopharyngeal mucosa is of some diagnostic significance. By the use of the nasopharyngoscope —Holmes's pattern—discharge in the posterior part of the nasal cavities, not observed by other methods of examination, may be detected and even traced to the ostia of the posterior group of sinuses. The instrument devised on the principle of the cystoscope is passed along the floor of the nasal cavity—previously cocainized—until the distal end has passed through the choana. By appropriate manipulations the various intranasal structures may be brought under inspection.

X-RAY TEST.—The recent improvements effected in technique, whereby a radiograph of the base of the skull is obtained by passing the rays through the vertical diameter of the head, have led to its more frequent employment in the diagnosis of suppuration in the posterior ethmoidal and sphenoidal air-sinuses (*Plate IV*, D, p. 74). These cavities appear in the picture side by side with very little overlapping and their shadows may be accurately interpreted not only in health but in unilateral and bilateral diseased conditions. A lateral radiograph is of service prior to operation upon the sphenoidal sinus. The size and depth of the cavity and the position of its anterior wall in relation to the floor of the anterior and middle cranial fossæ are thus ascertained. Information is also derived as to the thickness of the anterior wall of the sinus. Stereoscopic radiographs in the antero-posterior tilted position demonstrate best the relative positions of the ethmoidal and sphenoidal cells to the other sinuses.

THE EXPLORATION TEST.—In comparatively few instances is it found possible to inspect the sphenoidal ostium by anterior rhinoscopy without preliminary removal of the middle concha or of its posterior part. The observation can be made in exceptional cases of atrophic rhinitis, or sometimes after cocainizing the walls of the olfactory sulcus and introducing the thin blades of Killian's long speculum (median rhinoscopy). Pus may be seen issuing from the ostium with the aid of the nasopharyngoscope. By removal of the middle concha, if the nasal septum is not deflected, the nasal portion of the anterior wall of the sinus may be sufficiently exposed to bring the ostium into view. Pus, sometimes pulsating, may then be observed. If pus is not visible, a tampon of wool should be placed against the ostium and the patient directed to sit with the head inclined forwards. On the removal of the plug, the presence of pus on its posterior surface will testify to its origin in the sinus. On the other hand, when the wool tampon is laid over the orifice after careful cleansing of the area, and the patient throws the head backwards, the presence of pus on the anterior exposed surface of the pledget will raise the suspicion of posterior ethmoidal disease.

The above test may be supplemented by inserting through the sphenoidal ostium, if sufficiently large, a probe dressed with cotton-wool ; or by

6

inflating the sinus through a suitable cannula.   The average distance of the sphenoidal ostium from the anterior edge of the floor of the nasal vestibule is 8·2 cm. in the male and 7·2 cm. in the female.   If a negative result is thus obtained and accumulation of secretion again occurs in this area, its source lies probably in the posterior ethmoidal cells.   P. and E. Watson-Williams advocate and practise diagnostic exploration of these cells by means of a blunt straight trocar and cannula to which is attached a suction syringe (*see* p. 76).   The procedure is carried out without preliminary removal of the middle concha, and the trocar is passed either by the middle or superior meatal route.   A similar procedure is carried out upon the anterior bony wall of the sphenoidal sinus.

Thus, presumptive evidence of suppuration in the posterior group of sinuses is furnished by a combination of such symptoms as post-nasal discharge, neuralgic pains and visual disturbance, and is rendered more probable when pus is observed in the olfactory sulcus, in the superior meatus and on the vault of the nasopharynx.   The diagnosis becomes certain when discharge is seen in the sphenoidal ostium, or can be removed from the interior of the sinus or from the posterior ethmoidal cells.

CHAPTER XII.

TREATMENT OF CHRONIC SUPPURATION IN THE PARANASAL SINUSES.

THE two main factors in the treatment of chronic nasal sinus disease are : (1) The establishment of drainage ; (2) The removal, if possible, of the cause. The treatment of chronic suppuration in the sinuses is still essentially operative. Numerous operative procedures have been tried with a view to removal of the cause and to establish drainage, but there is no single operation which will meet the requirements of every case. Up to the present time, the employment of vaccines in longstanding cases has not given results sufficiently encouraging to justify their general use as a substitute for operation. Friel has effected a cure in cases of chronic maxillary sinus suppuration by means of zinc ionization, the cannula through which the zinc solution is injected into the cavity being fitted with the electric wire which carries the current.

In every case in which active interference is contemplated, it is necessary to consider whether the end in view will be best obtained (*a*) by establishing the maximum of drainage with the minimum of destruction of the mucous membrane of the cavity, or (*b*) by complete detachment of the diseased mucous membrane and an attempt to obliterate the cavity by removal of one or more of its osseous walls.

The adoption of one or other method will depend upon various factors, such as the actual sinus affected, the number of sinuses involved in a particular case, the chronicity of the discharge, and certain other considerations, e.g., the age and sex of the patient and the experience gained by the individual surgeon in his earlier work. These points will be considered in more detail when dealing with the treatment of each cavity.

The Maxillary Sinus.—As in the treatment of all the paranasal sinuses, in dealing with the maxillary antrum the method of choice should be the establishment of drainage, by conservative methods if possible, but radical when necessary. Thus intranasal drainage of the antrum through an opening made into the inferior meatus followed by a course of lavage through the naso-antral opening may be all that is required, but, when the disease has been of long standing, the more radical operation through the canine fossa, with. if necessary, the removal of all the lining mucosa, may be required.

The choice of alternative routes is the practical question which the surgeon must consider. In a considerable proportion of chronic cases drainage and lavage established by the nasal route will effect a cure ; in others again this procedure fails as, in consequence of the pathological changes already present in the lining membrane of the sinus, the septic

process will not yield to this simple measure. It is often difficult to
determine, before operating, what degree of change has taken place in
the mucous membrane. Neither the duration of the discharge nor the
density of the shadow obtained by transillumination will provide the
necessary information. On the other hand, improvement in the tech-
nique of radiography and experience in the interpretation of the radiographs
have undoubtedly come to the assistance of the operator. By its aid he
may recognize, in the one case, the œdematous swelling of the superficial
layer of the mucosa, characteristic of the acute and subacute cases and
more readily relieved by simple drainage and, in the other, the less
swollen but denser shadow of the thickened periosteal layer present in
the chronic cases. When the latter is associated with discharge in which
the mononuclear leucocyte predominates and a streptococcus is revealed
on bacteriological examination, then treatment by drainage alone is less
likely to prove successful. In these circumstances removal of the lining
mucous membrane is the more appropriate procedure, which can only be
efficiently carried out after opening the sinus through the wall of the canine
fossa. The X-ray examination of the sinus after the use of lipiodol by the
displacement method may help the surgeon to make up his mind, as the
condition of the mucosa is more easily determined in this way.

   The question of anæsthesia in operations upon the maxillary sinus,
and indeed in the case of all the sinuses, is of considerable importance.
When a general anæsthetic is employed the ideal method of administra-
tion is obtained by the use of intratracheal ether. The manipulations
of the surgeon are not interfered with and there is no anxiety regarding
the entrance of blood into the lower air-passages. If the apparatus is
not available, Junker's inhaler may be used through the mouth and the
nasopharynx plugged with gauze or with a sponge, anchored externally
by means of tape. When, in the case of the maxillary sinus, a local
anæsthetic is adopted, excellent anæsthesia results from blocking of the
maxillary trunk, supplemented by a submucous and subperiosteal injec-
tion in the canine fossa. Novocain and not cocaine is employed for this
purpose. The injection consists of 4 to 5 c.c. of a $\frac{1}{2}$ or 1 per cent
novocain solution to which have been added two drops of a 1–1000
solution of adrenalin. Whatever method of anæsthesia is adopted,
gauze strips impregnated with 10 per cent cocaine, to which is added an
equal quantity of adrenalin (1–1000), should be applied to the inferior concha
on both sides of the nose, before the operation is commenced. Artificial
light, obtained either by reflection from a forehead mirror or by using an
electric headlamp, offers the best means of illuminating the field of operation.

   1. *The Intranasal Route.*—The first step consists in the removal of the
anterior third or less of the inferior concha. This preliminary procedure
has a threefold object ; it gives the necessary access to the lateral
meatal wall ; it allows the patient during the after-treatment to intro-
duce the cannula into the sinus with greater ease ; and it provides better
drainage and aeration of the sinus. Care should be taken not to destroy
an unnecessarily large portion of the concha.

   An opening is next made in the lateral wall of the inferior meatus by
means of Tilley's frontal sinus burrs, care being taken to do so as far

forward as possible. Punch forceps, Grünwald's, Blakesley's or Luc's pattern, are then used to remove the fragments of bone and to enlarge the opening backwards. Enlargement of the opening forwards, if necessary, may be effected by the intro-duction of Spiess's or Ostrom's specially curved punch forceps, or by wearing down the anterior edge of the aperture with special rasps. It is important that the opening should be a large one, as contraction and cicatrization tend to occur ; consequently failure to effect a cure may result. Packing the sinus or the nasal cavity is unnecessary save in exceptional circumstances such as arise from undue hæmorrhage. In twenty-four or forty-eight hours the antrum is washed out by means of a specially con-structed cannula resembling a silver Eustachian catheter to which a Higginson's syringe or nasal douche is attached. A warm, sterile saline solution is employed,

Fig. 48.—Operation on the maxillary sinus through the canine fossa wall (Caldwell - Luc). The buccal incision.

and the procedure is repeated, at first morning and evening, and later less frequently, until the discharge ceases. A weak solution of iodine or silver nitrate may be found useful if the discharge tends to persist.

2. *The Canine Fossa Route (Caldwell-Luc operation).*—As an additional precaution against the downward passage of blood, a plug of gauze or a sponge with tape attached should be placed between the last upper molar tooth and the inside of the cheek. The upper lip is elevated and main-tained in that position by a suitable retrac-tor ; an incision along the gingivo-labial fold divides the soft structures down to the bone, being carried from the zygomatic process medially to the canine ridge (*Fig.* 48); the periosteum is raised in an upward and downward direction, and the bone forming the canine fossa is exposed, care being taken at this stage not to injure the infra-orbital nerve in the superior part of the fossa. With chisel and mallet an opening is made in the bone and, when the mucous membrane of the sinus is exposed, the aperture should be enlarged in a medial direction, until the angle of union between the facial and nasal walls of the sinus is reached (*Fig.* 49).

Fig. 49.—Operation on the maxillary sinus (Caldwell-Luc). Opening in the canine fossa wall, exposing to view the lateral wall of the inferior meatus.

If the mucosa of the sinus lining the canine wall has not as yet been removed, this is now done, and the interior of the sinus is mopped out and carefully inspected. This is facilitated by the use of temporary plugs of gauze moistened in hydrogen peroxide to control the oozing. In a number of cases the mucous mem-brane covering the alveolar recess or floor is considerably thickened and

may with advantage be removed with a sharp spoon or elevator, while that lining the other walls of the cavity will recover as the result of drainage and lavage and therefore should not be interfered with.   Some surgeons advocate the complete removal of the lining of the antrum, but the tendency is for operative interference to be as conservative as possible. It is known that epithelial regeneration in the antrum takes place very quickly after removal.   The ciliated columnar epithelium and glands even recover, but little is known as to whether normal function is regained. Therefore, it seems that if part of the lining can be safely left it should not be removed.

At this stage the gauze strip soaked with cocaine and adrenalin should be removed from the nasal cavity, the anterior portion of the inferior concha divided with scissors and then snared (some operators prefer to do this later through the naso-antral opening).   When this has been done, the naso-antral opening is made by the chisel introduced through the canine aperture.   It is applied vertically to the medial wall of the sinus (lateral wall of the inferior meatus) as near as possible to the nasofacial angle, so that the communication may extend close to the nostril and thus facilitate the patient's introduction of the cannula.   The chisel is then applied horizontally, first along the superior edge of the inferior meatal wall and then close to the floor of the nose.   The rectangular piece of bone, thus partially detached, is removed with forceps (*Fig.* 50).   As a rule, during this procedure, the nasal mucous membrane is left intact and is now brought into view. A small ridge of bone often left in the lower part of the window should be chiselled away to the level of the nasal floor.   With a fine-bladed knife the exposed portion of nasal mucous membrane, corresponding to the size of the bony aperture, is divided and removed.   The cut edge of the inferior concha and the lower part of the surface of the nasal septum are thus brought into view (*Fig.* 50).

Fig. 50. — Operation on the maxillary sinus (Caldwell-Luc). A counter-opening has been made in the lateral wall of the inferior meatus, through which is seen the inferior concha with its lower edge removed.

Before completing the operation in those cases in which it has been deemed necessary to remove the alveolar mucosa, the nasal mucous membrane which occupied the area corresponding to the window made in the lateral nasal wall may, in place of being removed, be turned down into the floor of the sinus, anchored with catgut and thus used as a flap, though in most cases this flap degenerates.   The cavity is finally inspected to see that no gauze plug has been overlooked.   The incision in the buccal mucoperiosteum may be sutured with two or three catgut stitches.

As a rule, neither the antrum nor the nasal cavity requires to be packed and it is greatly to the advantage of the patient to be able to dispense with plugs.   Troublesome hæmorrhage, necessitating plugging, may be

encountered towards the end of the operation, if the lateral posterior nasal branch of the sphenopalatine artery has been injured by the too free removal posteriorly of the lateral wall of the inferior meatus ; packing the cavity is then necessary. The after-treatment is similar to that carried out when the sinus is opened by the intranasal route. During the first two or three days a mouth-wash should be used, and only fluid nourishment given until the buccal wound has healed. Some surgeons deprecate post-operative lavage of the sinus.

When removal of the entire muco-periosteal lining of the antrum is contemplated, either in cases previously unrelieved by simple drainage or when this radical procedure is adopted at the outset, it can only be done satisfactorily by opening the cavity through the canine fossa. The detachment of the mucosa from the bone in one or more pieces may be effected by suitable periosteal elevators. It has been demonstrated experimentally in animals that a new mucous membrane with ciliated epithelium grows in from the nasal cavity through the naso-antral opening in the lateral wall of the inferior meatus and relines the interior of the sinus.

Denker describes and practises an operation in which the opening in the canine fossa is enlarged medially so as to include the removal of the inferior part of the lateral bony margin of the pyriform opening of the nasal cavity of the same side. The mucoperiosteum is raised from the anterior part of the floor of the nose and the lateral wall of the inferior meatus. This wall is then removed from before backwards so as to establish a sufficient aperture for the drainage of the antrum. After curetting the lining membrane of the sinus the muco-periosteal flap which covered the nasal aspect of the lateral wall of the inferior meatus is turned into the floor of the sinus in the manner already described. The advantage claimed for this method is the better inspection of the interior of the antrum both during and after the operation. In Canfield's operation there is the same purpose in view, but the mode of procedure is different. The operation is performed by the endonasal route and not through the mouth.

The Frontal Sinus.—In a small proportion of cases of chronic frontal sinus suppuration, operative interference may be withheld, e.g., when, as is sometimes the case, the cavity is small ; when the patient is free from headache or pain in the region of the sinus ; when his mental and bodily vigour are unimpaired by the small amount of discharge which is daily secreted. In these circumstances, occasional inspection of the nasal cavity and the removal of any polypoid mucosa which may have developed in it may prove sufficient treatment. In other words, the existence of a small quantity of purulent discharge is not in itself an indication for interfering with the sinus.

On the other hand, the occurrence of headaches, a state of mental depression and aprosexia, and those constitutional symptoms which are regarded as dependent upon a chronic toxæmia, are indications for interference. Further, when there is evidence of the development of the extension of the inflammation into the orbit or cranium, active treatment should not be delayed.

As in the case of the maxillary sinus, when operation is contemplated, two routes of access to the frontal sinus are open to consideration ; the establishment of free drainage and aeration of the cavity either (*a*) by way of the nasal cavity or (*b*) by obtaining access through an external, cutaneous incision. In certain circumstances, however, it may be considered advisable to remove the lining membrane of the sinus and even one or more of its osseous walls with the object of making a thorough exploration of the cavity and then obliterating it. This more radical procedure should be reserved for those cases in which the onset of intracranial symptoms demands more complete investigation, or when more conservative operations have failed to effect a cure. Extensive removal of bone may not only lead to infection of the diploë of the cranial bones and the development of diffuse osteomyelitis but also to considerable disfigurement of the patient.

In no case, however, should a decision between the intranasal and external method of drainage be reached without careful preliminary study of postero-anterior and lateral radiographs of the paranasal sinuses. When the frontal cavity is of average dimensions, is devoid of accessory partitions and pockets and when there is obviously considerable available space between the nasal and frontal cavities for instrumental manipulation, the attempt may be made, in the first instance at any rate, to remove the underlying diseased ethmoidal cells and drain the cavity by intranasal operation. On the other hand, in the case of a large and irregular-shaped cavity with an orbital extension and with infected ethmoidal cells extending into the orbital roof, the external route is preferable. It is generally accepted that external operative treatment of the frontal sinus should not be undertaken without due consideration ; that drainage of the underlying ethmoidal cells, with removal of the middle concha to permit free drainage of the naso-frontal duct should be the initial operative step.

Intranasal Operation,—This method follows the lines of the operation already described in connection with the surgical treatment of acute suppuration in the frontal sinus (p. 67). Free removal of the diseased ethmoidal air-cells is essential with a view to preventing re-infection of the higher sinus. The further employment in chronic suppuration of specially constructed raspatories (Watson-Williams) with the object of enlarging the ostium frontale is a debatable point, as it may be followed by the formation of new bone and consequent narrowing of the passage before the healing of the sinus has taken place.

External Operation.—No hard-and-fast rules should be laid down in these cases, as modifications in technique will arise dependent upon the anatomical and pathological conditions present in each case. As already indicated, the principles which should guide the surgeon in planning his operation are, the complete removal of the infected ethmoidal air-cells, the establishment and maintenance of free drainage of the frontal sinus and, so far as possible, the avoidance of disfigurement of the patient, though this latter has become of less importance with the advance of plastic surgery.

A modification of the operation introduced by Jansen many years ago—embracing the principles just referred to—has been successfully

PLATE V

THE HOWARTH OPERATION ON THE FRONTAL SINUS
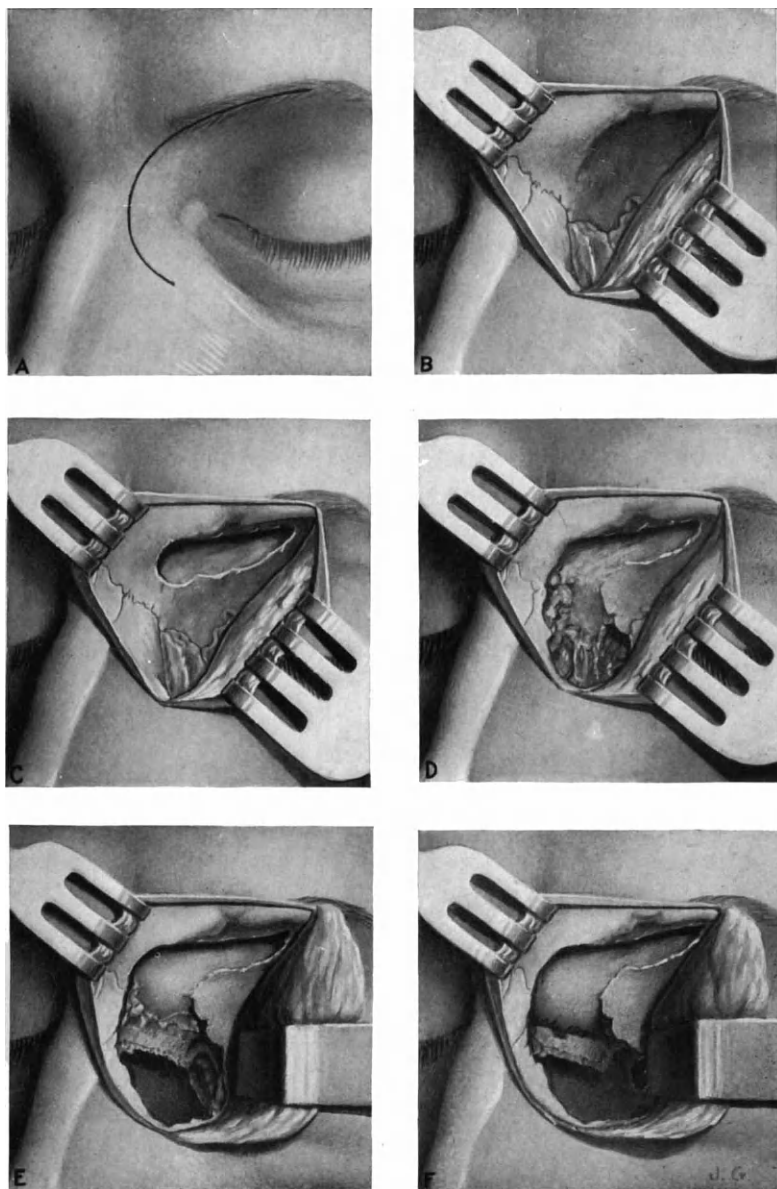
(A) The cutaneous-periosteal incision; (B) Exposure of the floor of the frontal sinus; (C) Removal of the floor of the frontal sinus; (D) Ethmoidal cells opened; (E) The nasal septum exposed to view after the removal of the middle concha and ethmoidal cells; (F) The enlarged ostium sphenoidale and superior margin of the choana are now visible.

employed by W. G. Howarth (*Plate V*). A curved incision com-
mencing beneath the supra-orbital margin is carried medial to the inner
canthus along the side of the nose. The periosteum is then divided
along the same line and raised from the roof and medial wall of the
orbit, the pulley of the superior oblique muscle being detached from its
notch in the bone and the lacrimal sac from its bony groove. These
structures along with the contents of the orbit are retracted laterally.
The frontal sinus is then opened a short distance above the lacrimal
groove and the whole floor of the cavity removed with forceps up
to the supra-orbital margin. Extensions of the ethmoidal cells into
the orbital roof are similarly dealt with. The lining mucous membrane
of the sinus, with the exception of the portion covering the bony floor, is
left untouched.

Attention is now directed to the removal of all the diseased ethmoidal
cells and to the establishment of
a large communication with the
nasal cavity. For these purposes
part of the ascending process of the
maxilla is removed. The anterior
and superior cells of the ethmoidal
labyrinth are then dealt with. The
remaining portion of the affected
cells, if necessary as far back as the
sphenoid bone, is taken away by a
bimanual method, the cells being
destroyed with the mastoid curette
introduced intranasally and the
débris removed with forceps through
the external wound. In order to
enlarge still further the fronto-
nasal duct and ensure efficient drain-
age, the rest of the ascending process
of the maxilla and part of the nasal
process of the frontal bone are
taken away, particular attention
being paid to the bony projection

Fig. 51.—Radical operation on the left
frontal sinus after removal of the anterior
osseous wall of the cavity. The floor of the
cavity and the ethmoidal cells are dealt with
as in *Plate V*.

from the frontal bone. A large firm-walled rubber drainage tube is
inserted, with its upper end lying in the anterior part of the sinus, its
lower end stitched to the ala nasi. The contents of the orbit are then
replaced and the skin incision completely sutured. The tube is removed
at the end of ten days. By preserving the anterior osseous wall of the
sinus disfigurement is thus avoided.

If obliteration of the sinus is decided upon, the operation just described
must be extended upwards by elevating the soft tissues with the peri-
osteum from the whole of the anterior osseous wall of the sinus. This wall
is then removed with gouge and bone forceps (*Fig.* 51). The mucous
membrane is detached by means of forceps from the vertical portion of
the cavity which is then cleansed and lightly packed with worsted or
gauze. The cutaneous-periosteal flap is replaced and the wound sutured

with the exception of the part through which the end of the packing protrudes.   After this is removed moderately firm pressure should be applied over the lower part of the forehead so as to maintain the raw surfaces in apposition with the object of effecting uniform obliteration of the cavity.

There are various obliterative or moderately conservative operations on the frontal sinus which cannot be discussed here.   The Killian operation, the first true radical operation, which by retaining the orbital ridge had the advantages of obliteration without the disadvantages of deformity, but which failed on account of the frequency with which a spreading osteomyelitis of the orbital margin supervened. Recently, an operation devised by Ferris Smith on the ethmoid and frontal sinus has shown how complete a radical operation can be performed with the total removal of the mucous membrane but with little deformity.

The Ethmoidal Labyrinth.—The treatment of chronic suppuration is one of the serious problems in the therapeutics of sinus suppuration. This is due in part to the position which the ethmoidal labyrinth occupies in the nasal cavity and, in part, to its extensions beyond the boundaries of the ethmoid bone.   It is often difficult, therefore, to determine the extent of the affected area.   Treatment, as in the case of the maxillary and frontal sinuses, may consist in opening and draining the individual cells affected, or in complete removal of a part or the whole of the labyrinth.

Intranasal Operations.—Most authorities agree that intranasal operation on the ethmoid cells has been found very satisfactory and should be preferred in the first place to the external route unless the frontal sinus as well as the ethmoid cells is involved.   These intranasal procedures have been grouped under four headings : (1) Dislocation of the middle concha, partial removal of the middle concha or the local removal of polypi ; (2) Simple opening of the bulla ethmoidalis, uncinate process or agger nasi cells ; (3) Opening of all the anterior cells, with simple punch forceps, without removal of the middle concha ; (4) Opening of the anterior and posterior cells with removal of the middle concha (*Plate VI*).   Here a conservative principle has been adopted as in the case of the sinuses already considered.

On the other hand, when all the anterior and posterior cells are affected, minor operations, frequently repeated, are very unsatisfactory : the patient becomes more sensitive and intolerant of interference at each successive sitting and, with the continuance of the discharge, in spite of what has been done, he becomes less and less inclined to undergo further treatment.

In this class of case, therefore, the whole of the diseased labyrinth may be dealt with at one operation by a block dissection, with complete removal of the middle concha, and the sphenoidal sinus, if necessary, opened at the same time.   This operation is actually a radical operation carried out intranasally.   It can be performed under local anæsthesia with the previous preparation of the nose as for any intranasal operation but with the addition of block anæsthesia of Meckel's ganglion

PLATE VI

INTRANASAL OPERATION ON ETHMOIDAL AIR·CELLS
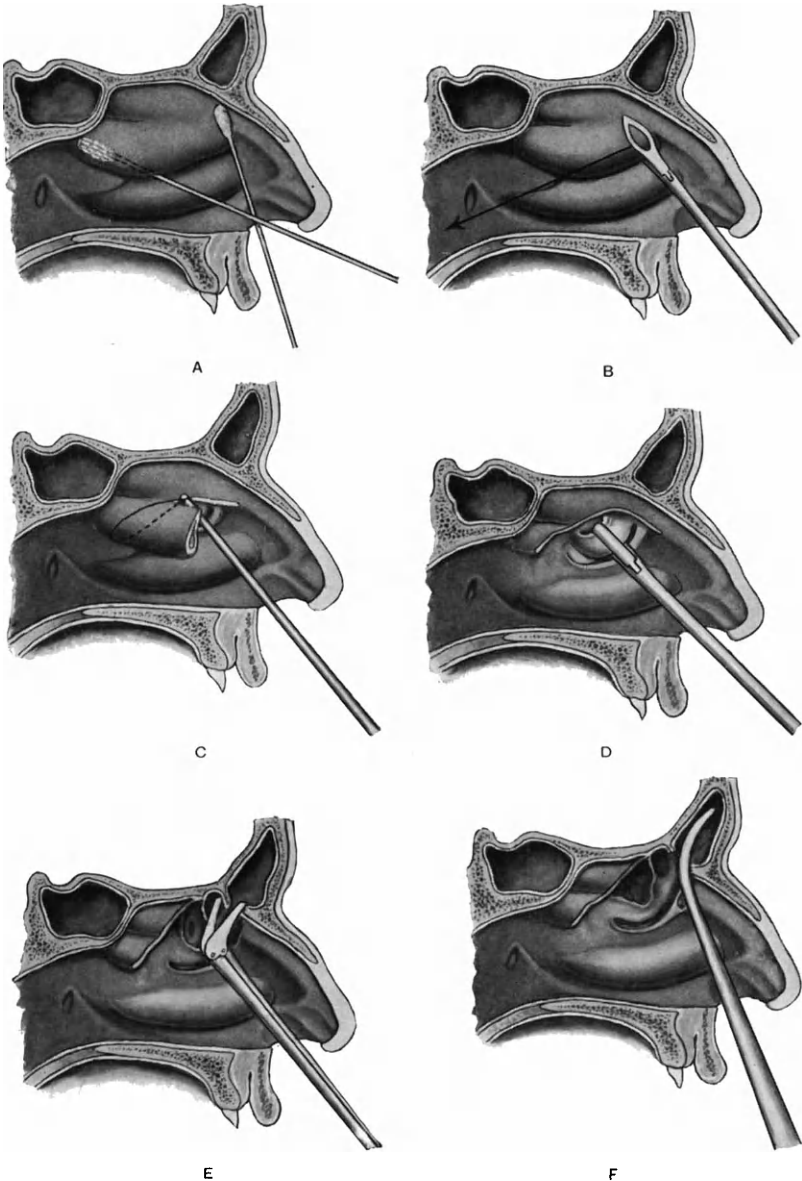
(A) Local anæsthesia by Sluder's method : a cotton-tipped probe, moistened with 70 per cent cocaine and with adrenalin, is passed lateral to the middle concha, towards the region of the spheno-palatine ganglion. A second cotton-tipped probe is passed as high up and far forward as possible in the nasal cavity to anæsthetize the nasal nerve ; (B) Removal of anterior end of middle concha with Blakesley forceps. The anterior end of the concha is firmly gripped with the forceps and pressure made in a downward and backward direction towards the nasopharynx ; (C) Removal of posterior part of middle concha with the snare ; (D) Opening of anterior ethmoidal cells with Blakesley or Gruenwald forceps. The posterior cells are similarly opened up, working lateral to the cut edge of the middle concha ; (E) Intranasal opening of frontal sinus ; (F) Frontal sinus probe in position.

and the nasal nerve by wool-tipped probes dipped in 70 per cent cocaine solution (*Plate VI*).

In the presence of diseased fronto-ethmoidal and maxillo-ethmoidal cells even such a radical intranasal measure as the above may not effect a complete cure of the discharge. Further, unforeseen accidents with fatal intracranial complications have occasionally arisen in connection with this line of treatment. The ethmoidal cell labyrinth, on the other hand, may be removed at one sitting by operating lateral to the vertical plane of the medial surface of the middle concha. The dangerous area of the nasal cavity is thus avoided and the olfactory perineural sheaths and the cribriform plate escape injury. The anterior end and greater part of the lower border of the middle concha are removed with Blakesley's forceps by a downward, backward movement ; the posterior end of the concha may then be detached with a snare. Working laterally with forceps the surgeon next removes the cell walls as far as the anterior face of the body of the sphenoid bone (*Plate VI*).

External Operation.—This method of approach to the ethmoidal labyrinth is advisable in certain circumstances : (1) When, in association with frontal sinus suppuration, the decision has been made to open the latter cavity, the ethmoidal cells are dealt with at the same time ; (2) When an external fistula above the medial angle of the orbit communicates with the labyrinth ; (3) In the presence of an orbital abscess or of acute inflammatory complications within the cranium. Some surgeons, however, advise and perform the external operation in all cases of chronic suppuration. This method gives good access to the diseased extensions of the ethmoidal cells in the roof of the orbit, and the whole field of operation with the dangerous areas in its immediate neighbourhood come under the direct observation of the operator. The procedure adopted follows the lines of the description of the external frontal operation given on page 88 ; it is completed in one stage.

The Sphenoidal Sinus.—With the exception of those cases in which an external operation on the ethmoidal cells is completed by opening the sphenoidal sinus, the latter cavity is treated by the intranasal route. Further, the operation should be conservative, and confined to the establishment of free drainage. The thinness of the walls of the cavity in so many cases, the frequency with which dehiscences may be present in the bone, and the numerous important nerves and vessels in close proximity to the lining membrane of the sinus, render the employment of curettes within the cavity extremely dangerous. Good lateral radiographs should be studied in all cases before the sphenoidal sinus is opened, so as to determine the anteroposterior and vertical diameters of the cavity.

Local anæsthesia may be employed alone, or combined with the administration of ether anæsthesia. The middle concha is completely removed, and, if the ostium sphenoidale is not brought into view by this procedure, removal of the wall of a projecting posterior ethmoidal cell may be necessary. In the majority of cases, however, the ethmoidal labyrinth has probably been previously dealt with. A sphenoidal

sinus hook is inserted into the ostium sphenoidale which is enlarged by pulling away the thin anterior wall forming its lower boundary.
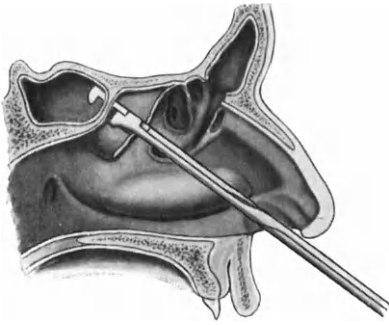
Fig. 52.—Sphenoidal sinus forceps in position preparatory to removal of anterior wall of the sinus.

Into the enlarged opening there is then passed one blade of the sphenoidal cutting forceps and a portion of the anterior wall is nibbled away in a downward and outward direction (*Fig.* 52). As the bone becomes thicker towards the floor of the sinus, there may be difficulty in removing the lower segment of the wall. As the aperture tends to contract, it should be made as free as possible. The interior of the sinus must not be curetted for the reasons just given. Occasionally, during the removal of the anterior wall of the sinus, considerable hæmorrhage, which necessitates packing, may occur from the sphenoidal branch of the sphenopalatine artery. Lavage may be practised, if deemed necessary, and post-operative granulations touched with silver nitrate.

CHAPTER XIII.

COMPLICATIONS OF SUPPURATION IN THE PARANASAL SINUSES. OTHER AFFECTIONS OF THE SINUSES.

ORBITAL AND OCULAR COMPLICATIONS OF SINUS DISEASE.

REFERENCE has already been made to the fact that orbital and ocular complications may arise in connection with suppuration of both the anterior and posterior group of sinuses and, to avoid repetition, it is convenient to discuss these together. The subject may be better understood if it is remembered that the anterior group—the frontal sinus, the anterior ethmoidal cells and the maxillary sinus—is contiguous to the roof, the medial wall and the floor of the orbit ; while the posterior group—consisting of the sphenoidal sinus and the posterior ethmoidal air-cells—is in immediate relationship to the posterior half of the medial wall of the orbit and to the superior orbital fissure and optic foramen. In consequence of the close anatomical relationships, there may arise, as the result of suppuration in the anterior group of air-cavities, orbital periostitis and abscess (usually subperiosteal) associated with œdema of the eyelids, chemosis of the conjunctiva and displacement of the eyeball with impaired mobility. Suppuration in the posterior group of sinuses may also give rise to subperiosteal orbital abscess, but more frequently the complications are retrobulbar neuritis, optic atrophy and paralysis of ocular muscles. The infection most commonly implicates the orbit by direct extension of the inflammation through the bony wall of the adjacent air-sinus with resulting cario-necrosis. In the event of rupture of the orbital periosteum, the tissues of the orbit become infected and there is a danger of septic thrombosis of the ophthalmic veins with secondary infection of the cavernous blood sinus. Early evacuation of the subperiosteal abscess is called for with drainage of the affected sinus or sinuses.

In orbital complications of the anterior group of sinuses, œdema of the eyelids is commonly the first sign that the inflammatory process has extended to the orbit ; this is followed by chemosis of the conjunctiva, proptosis, with occasionally lateral displacement of the eyeball, and diplopia (Fig. 53). If the condition is not treated, the abscess, which is at first subperiosteal, may perforate the periosteum and cause sloughing of the orbital tissues ; it may then give rise to septic thrombosis of the ophthalmic veins and the cavernous blood sinus and so cause death. When the posterior group of sinuses is the source of infection, retro-bulbar neuritis, optic atrophy, and paralysis of the ocular muscles may be met with, while central scotoma and peripheral contraction of the

field of vision, especially for colours, may be found.   In consequence of
the varying anatomical development of the posterior ethmoidal and
sphenoidal sinuses, the diminution in the visual fields may be bilateral,
although the sinus affection is limited to one side ; in some cases, again,
the signs are contralateral to the sinus affected.   The significance of
these symptoms and signs lies chiefly in the fact that they suggest nasal
disease, calling therefore, for an examination of the nose and even for
exploration of the sinuses, although
there may be no obvious suppuration.
When the ocular changes are uni-
lateral, the sinuses on both sides
should be examined with equal care.

When an orbital abscess due to one
of the anterior group of sinuses is
present, an external operation on the
affected cavity is as a rule necessary ;
simple œdema, however, may disappear
after the establishment of intranasal
drainage of the affected air-sinus, which
in most cases should be a preliminary
procedure.   A collection of pus in the
orbit should be evacuated at once, as
delay may lead to the loss of sight, or
even to a fatal issue as a result of a
secondary intracranial complication.

Before deciding upon operation in
cases with ocular symptoms, such as
those associated with retrobulbar
neuritis and scotomata, a very careful
examination of the sinuses should be
made and radiographs obtained.   It is
advisable, also, that the ophthalmolo
gist should be consulted and the case

Fig. 53.—Left orbital abscess secondary
to suppuration in the frontal sinus.
Œdema of the left upper eyelid, narrowing
of the palpebral fissure, proptosis with
downward and lateral displacement of left
eyeball.

discussed with him.   There is undoubtedly a group of cases in which
nasal examination reveals little or no change from the normal, but where
exploratory operation upon the posterior sinuses is followed by disap-
pearance of the eye symptoms.   Cases of a similar nature, however,
recover without such interference.

INTRACRANIAL COMPLICATIONS.

Intracranial complications consequent upon sinus suppuration may
arise as the result of the infection spreading directly to the brain and its
membranes through the cerebral wall of the affected sinus, or indirectly
by way of the orbit.   The inflammation may extend to the intracranial
structures by osteoclastic erosion of the bony wall of the sinus or by
septic thrombosis of the diploic and perforating osseous veins in the
cerebral wall of the sinus.   When the infection passes by way of
the orbital cavity, it is conveyed thence by the superior and inferior

ophthalmic veins causing septic thrombosis of the cavernous blood sinus. If extension should take place from the orbit along the pial sheath of the optic nerve, then leptomeningitis supervenes.

Complications may arise in connection with both acute and chronic sinus suppuration. They are rare in cases of disease of the maxillary sinus, but more than one case of cavernous sinus thrombosis has been reported in which this cavity was regarded as the primary source of the infection. Frontal lobe abscess, with or without an associated extra-dural or subdural abscess, is most prone to supervene upon inflammation of the frontal sinus. This sinus is the most frequent source of an intracranial complication, and frontal lobe abscess and leptomeningitis are the commonest of all the complications that may arise secondary to paranasal sinus disease. Leptomeningitis developing in connection with the sphenoidal sinus is usually secondary to septic thrombosis of the cavern-ous blood sinus, the leptomeninges being infected by retrograde extension of the thrombus along the pial veins opening into the blood sinus.

The diagnosis of *abscess of the frontal lobe*, one of the silent areas of the brain, may be attended with considerable difficulty owing to the absence of localizing phenomena. In addition to the usual signs of progressive cerebral compression, evidence of which may be seen in headache, vomiting, slow pulse, subnormal temperature, and delayed cerebration, there may be observed a transient aphasia and contralateral convulsive seizures when the abscess is situated near the base of the third frontal or ascending frontal convolution. Macewen has emphasized the occurrence of pupillary changes in these cases. When the abscess is large, the pupil on the side of the lesion is in a state of stabile mydriasis ; when the abscess is small, the pupil may be contracted and react sluggishly. In one reported case of left frontal lobe abscess complicating acute inflam-mation of the frontal sinus, in addition to signs of cerebral compression, a contralateral Babinski's phenomenon and absence of the abdominal reflexes on the side opposite to the lesion were noted (J. S. Fraser).

In septic *thrombosis of the cavernous blood sinus* the orbital and ocular signs characteristic of the disease are, at first, usually unilateral ; as the infection progresses the other eye may become similarly affected and, simultaneously, there may be improvement in the condition of the first eye. The clinical phenomena depend upon two main factors, (a) the obstruction of, and the septic process in, the ophthalmic veins, and (b) interference with the action of the ocular muscles. In consequence of the venous obstruction due to septic thrombosis of the ophthalmic veins, there arise œdema of the eyelids, chemosis of the conjunctiva, exophthalmos or proptosis of the eyeball and distension of the retinal veins and blurring of the optic disc. Interference with the action of the ocular muscles causes impairment in the movements of the eyeball with its final complete fixation, alteration in the size of the pupil and ptosis of the upper eyelid. These phenomena are partly of mechanical origin consequent upon orbital œdema causing the displacement of the eyeball and stretching of the attached muscles, and in part are the result of paralysis of the oculo-motor nerves traversing the lateral wall of the cavernous blood sinus.

The condition must be differentiated from that of orbital abscess secondary to suppuration in one of the paranasal air-cavities. In both, œdema of the eyelids, chemosis, exophthalmos and impaired mobility of the eyeball are present ; but in cases of orbital abscess the eyeball is not only displaced forwards but usually also laterally, or downwards and laterally, according to the situation of the abscess in relation to the air-sinus affected. The pupils as a rule are equal and react actively, but the retinal veins may be distended in consequence of pressure upon the ophthalmic veins due to the orbital œdema. Further, the other eye does not become affected, the condition remaining unilateral. The differential diagnosis is sometimes difficult, however, and may be complicated by the fact that both orbital abscess and thrombosis of the cavernous sinus may be present in the same case.

For the signs of *acute leptomeningitis*, the reader is referred to the chapter dealing with the intracranial complications of aural suppuration (Chapter XXXVIII).

MUCOCELE OF THE PARANASAL SINUSES.

Occasionally there arises, in connection with the anterior ethmoidal cells and frontal sinus, a slowly progressive and painless affection characterized by the formation of a swelling situated above the medial canthus of the eye, or occupying the area beneath the medial and middle thirds of the supra-orbital margin. As the swelling slowly increases, the eyeball is displaced forwards and laterally, or forwards, downwards and laterally, depending upon the position occupied by the swelling (*Figs.* 54, 55). The displacement of the eyeball and the diplopia which this may produce, and sometimes an accompanying epiphora, are in the majority of cases the phenomena which cause the patient to seek the advice of the ophthalmic surgeon.

The history which is obtained will reveal the fact that the orbital swelling has probably existed for many months or even for a number of years ; but, owing to the absence of pain, and to the fact that it has caused no inconvenience, little notice has been taken

Fig. 54.—Mucocele of the right anterior ethmoidal cells, showing a swelling above the medial canthus.

of it. In some cases it may be ascribed to an injury ; in others, no such history is obtainable. In addition to the displacement already referred to, the palpebral fissure may be found somewhat narrowed ; the eyelid is not discoloured, nor is it œdematous, and there is an entire absence of inflammatory mischief. The movements of the eyeball are

for a time good save for a slight mechanical limitation medially and upwards ; the pupil reacts to light ; there is no change in the fundus. On palpation, tenderness is not elicited and the skin is freely movable over the swelling. Pressure will not, as a rule, reduce it. The medial edge of the swelling is hard, producing the impression of bony thickening. As the finger passes on to its more projecting part, a feeling of elasticity is obtained, and the prominence appears to yield under the pressure.

Nasal examination discloses no evidence of discharge ; nor, as a rule, is there any alteration in the normal appearance of the intranasal structures. In cases of ethmoidal mucocele, however, the lateral wall in the middle meatal area may bulge or project medially into the nasal cavity.

The clinical history and appearances here recorded are very characteristic of mucocele of the ethmoidal or frontal sinuses. The term is applied to an accumulation and retention within the sinus of a mucous secretion associated with obstruction of its outlet. One or more of the walls of the cavity become thinned and absorbed, and there may actually be some distension of the sinus. A similar affection has been described in connection with the sphenoidal sinus, but it is doubtful if a parallel condition has been found in the antrum. In all probability the cases which have been described as such were periodontal cysts which, in their growth, caused thinning and expansion of the antral walls. As a rule the thin orbital wall of the ethmoidal and frontal sinuses becomes absorbed and, in the case of the latter cavity, a considerable area of the posterior cerebral wall

Fig. 55.—Mucocele of the right frontal sinus, showing swelling beneath the supra-orbital margin, with narrowing of the palpebral fissure, and forward, downward, and lateral displacement of the right eyeball.

disappears, thus exposing the dura mater. Absorption of part of the anterior wall of the frontal sinus has been recorded. The fluid contents of the mucocele vary both in consistence and colour. In the majority of cases it is thick, tenacious, or even gelatinous ; in colour it may be white and opalescent, or greenish or greyish-brown ; occasionally it may present a clear, serum-like character, resembling cerebrospinal fluid. Cholesterin crystals may be observed in it ; as a rule, the contents are sterile. If, as sometimes occurs, the cavity becomes infected, acute inflammatory symptoms develop, and the mucocele is converted into a pyocele.

The etiology of the condition is still somewhat obscure. Injury has been alleged as a causative factor ; possibly a preceding catarrhal

condition may lead to blocking of the ostium of the sinus, followed by accumulation within the cavity and gradual thinning of the least resistant of its walls.   Some authorities consider that the condition is primarily one of cyst formation in the lining membrane of the sinus.

The diagnosis is based mainly on the clinical history and appearances.   The limitation of the swelling to the area immediately above the medial canthus, associated with projection of the ethmoid wall into the middle meatus of the nose, is strongly suggestive of an ethmoidal mucocele ; but the X-ray plate should be used to assist the diagnosis. An osteoma of the frontal or ethmoidal cells may give a very similar history and clinical picture, but the orbital swelling does not give the elastic or fluctuating sensation on palpation, and the X-ray shadow is very opaque.

TREATMENT of the ethmoidal mucocele should be intranasal.   With cocaine anæsthesia, the middle concha is removed and the projecting ethmoidal wall is broken down and a large opening established ; pressure on the orbital swelling will evacuate the contents into the nose.   If the intranasal opening is made sufficiently large, reaccumulation should not take place.   In the case of the frontal sinus mucocele, an external operation must be performed through an eyebrow incision and the orbital roof exposed.   The remaining part of the floor of the sinus is removed, and a large communication is made with the nasal cavity by destroying the anterior ethmoidal cells ; the lining membrane of the sinus is not interfered with.   A large drainage tube is passed from the sinus into the nasal cavity and left in position for ten days or a fortnight.   The external wound is sutured.

DENTAL (PERIODONTAL) CYSTS IN CONNECTION WITH THE MAXILLARY SINUS.

Periodontal cysts, originating in connection with the periodontium or periosteum of a diseased upper premolar or molar tooth, may, in the process of growth, gradually invade the cavity of the antrum.   If left undisturbed, the cyst, in the course of its development, will cause bulging and absorption of one or more of the bony walls of the sinus. Consequently, swelling and thinning of the facial wall above the alveolar border are observed, often with fullness of the cheek ; a projection into the anterior part of the inferior meatus of the nose produces some degree of nasal obstruction ; and, finally, bulging of the hard palate may develop as the cyst enlarges.   Palpation of the facial or palatal distension may give a crackling sensation to the finger, or the thinned bone may yield to the pressure, only to be restored to its previous position when the pressure is relaxed.

Transillumination, in some cases, may demonstrate greater brilliancy on the affected side, but in many the thick viscid nature of the cyst contents produces opacity.   A radiograph will reveal a dense area occupying the antrum, sometimes with the wall of the cyst defined.

Not infrequently pyogenic infection of the cyst occurs ; the pain and inflammatory symptoms thus produced causing the patient for the first

time to seek advice. The absence of nasal discharge and the signs above enumerated should differentiate the condition from that of antral suppuration.

Malignant disease of the antrum may also be associated with thinning and distension of the walls of the cavity. In these cases, however, the more rapid development of the growth, associated with pain, with a wider distribution of the swelling, possibly involving the roof of the sinus, displacing the eyeball and obstructing the nasal cavity, are significant of the malignant nature of the affection.

Brown Kelly has drawn attention to a form of dental cyst which he has named 'latent dento-antral cyst', in which the cyst invades the sinus without showing any external signs so long as it remains a closed cavity. If the cyst should burst, there will be a sudden discharge of pale yellow or almost colourless fluid from the corresponding nostril, with rapid diminution and gradual cessation, followed by a period of quiescence. The patient may experience recurring attacks of this nature. In these cases, transillumination, X rays and exploratory puncture should be employed. If the cannula enters an intact cyst, it cannot be syringed out unless a second cannula is introduced to serve as an exit for the fluid. Suction, however, may withdraw the contents. If the cyst has ruptured, the washings will return by the nasal passage.

Various operations have been devised for the treatment of dento-antral cysts. When the cysts are small, the wall is exposed through an incision in the gingivo-labial fold, the projecting portion of the wall is removed and, through the opening thus made, the lining membrane of the cyst is detached and removed. The bony cavity is then lightly packed and the incision is stitched, leaving an aperture for the gauze drain. Packing and syringing are continued until obliteration is attained. To avoid this somewhat prolonged after-treatment, the cavity, dealt with as above described, may be allowed to fill with blood-clot and the incision be completely sutured (Dan McKenzie). In cases of large cyst, the operation described in connection with the treatment of chronic suppuration of the antrum may be employed (Caldwell-Luc). As the medial portion of the cyst wall has probably blended with the lateral wall of the inferior meatus, a large nasal opening is made through the latter ; the mouth wound is sutured and the cyst is washed out for a short period by means of a cannula introduced through the nostril. As an alternative procedure the whole bony wall of the cyst may be removed thus opening up the antral cavity. The operation is completed by establishing an antro-nasal opening and suturing the mouth wound.

NASO-ANTRAL (CHOANAL) POLYPI.

The patient—usually a child or a young adult—complains of unilateral nasal obstruction which may later become bilateral. This is associated with an accumulation of mucous discharge in the obstructed side of the nose. Snoring is probably a symptom and the speech becomes 'thick', or some degree of rhinolalia clausa is noticed. There is an absence of pain, and aural symptoms are rarely met with. The facies of the child

may resemble that observed in cases of adenoids and, unless a physical examination of the nasal cavities is made, an erroneous diagnosis of adenoids may be arrived at.

Anterior rhinoscopy may reveal nothing abnormal save a swollen inferior concha and an accumulation of mucus on the floor of the nose on the obstructed side. On the other hand, a polypus may be visible in the anterior part of the nasal cavity. In those cases in which the inferior concha is turgescent, cocaine should be applied and a second inspection made. It may now be possible to see a polypus far back in the nasal cavity and, by careful examination, to trace the same extending upwards and lateral to the middle concha in the middle meatal region. If the end of a probe is bent in the form of a small hook, it is sometimes possible to pass it round this stalk-like prolongation.

Posterior rhinoscopy should always be attempted, and, if successful, it discloses a smooth, greyish-white, spherical mass occupying one choana and projecting through it into the nasopharynx. It may conceal the posterior free edge of the septum nasi and even part of the choana of the other side (*Plate III*, 6, p. 70). The polypus varies both in colour and in size in different cases. Thus, it may have a bluish or pinkish tinge. When small it may simulate the posterior end of the inferior concha, with which it is sometimes confused ; but it never presents the mulberry-like appearance which the enlarged posterior end of that body may assume (*Plate III*, 5). When the polypus is large, it may project below the soft palate and is visible when the throat is inspected. On palpation with the finger passed behind the soft palate, a smooth, somewhat movable, and soft polypus is felt which, if not too large, may be pushed forwards into the nasal cavity. The appearance seen in the mirror and the sensation conveyed to the finger will differentiate the condition from that of fibrous tumour of the nasopharynx.

As a rule, the unilateral single polypus with the appearances just described, occurring in a young person, is a typical clinical picture of the naso-antral polypus. Similar polypi have been described as arising in the sphenoidal sinus and ethmoidal cells.

The probable origin of the polypus from the antrum should be further investigated by means of transillumination and the X rays. When the first is used, the crescentic tache on the affected side may be found brighter than that on the normal side, though this is not always the case, as the two crescents may illuminate equally, or that on the affected side may be darker than that produced by the normal antrum. In the radiograph, which is of greater diagnostic value, an opacity is found on the diseased side. If the suspected antrum should show no shadowing, doubt will be raised as to the origin of the polypus in that sinus.

The naso-antral polypus arises from the mucous membrane of the maxillary sinus, an origin which was first pointed out by Killian. The morbid condition of the antrum is probably of catarrhal origin and, as the swelling increases, a small polypus develops. This becomes drawn through the accessory ostium, in the neighbourhood of which the polypus originates. Being nipped by the margin of the ostium,

the polypus increases in size within the nasal cavity and, following the line of least resistance, passes backwards to the choana and nasopharynx. In structure it closely resembles that of the ordinary nasal polypus, while scattered throughout the stroma are a number of pseudo-cysts. The fluid evacuated, when the polypus is removed, is derived from these false cysts.

The polypus may be removed by the snare passed through the anterior naris and, when the growth is small, no difficulty will be experienced in doing so. When large, however, it will be found that the ordinary snare loop will not encircle it ; it is necessary, in these cases, to introduce the snare threaded, but with the wire unfixed, so that a sufficiently large loop may be passed round the free end of the polypus ; to effect this, the finger of one hand is introduced through the mouth into the nasopharynx and the wire loop is guided over the projecting mass by the aid of the finger. The wire is then drawn into the barrel of the snare, fixed, and pulled taut.

In some of the cases treated in this way a cure has resulted, the antral portion being torn from its attachment within that cavity.

If recurrence takes place, or if it is thought advisable to adopt more radical measures at the outset, the antrum should be opened through the canine fossa, as is done in the treatment of chronic suppuration in that cavity. The intranasal attachment is dissected off the wall of the sinus, and a careful inspection of the rest of the lining membrane of the cavity is carried out. A counter-opening is made in the lateral wall of the inferior meatus and the buccal wound is sutured. The nasal part of the polypus is then removed with Luc's forceps passed from the anterior naris ; or, by means of Kuhn's or Loewenberg's curved post-nasal forceps, the mass is brought out through the mouth.

SIMPLE CHRONIC HYPERPLASIA OF THE MAXILLA.

Under this title F. H. Westmacott has described a bony thickening of the upper jaw in young adults. In eight cases observed by him, seven occurred in women ; the ages of the patients ranged from 17 to 30 years. The condition is usually confined mainly to the alveolar border of the maxilla, between the canine ridge medially and the zygomatic process laterally, though the latter becomes in part involved. The alveolus is greatly broadened and presents a smooth surface from which the teeth slightly project. The cavity of the sinus is encroached upon and may become obliterated. A fullness or protrusion is visible on the lower part of the cheek, and pain resembling toothache is complained of. Other similar cases have been reported (Douglas Guthrie, W. G. Howarth, etc.).

The condition is limited to the parts mentioned and the process would appear to be a reversion to the embryonic type of bone. The newly-formed osseous tissue is highly vascular and cancellous. The bone-corpuscles stain well and the interstices of the bone are occupied by actively proliferating osteoblasts, among which are a few osteoclasts. There is no evidence of granulomatous inflammation or of inflammatory or suppurative changes. The covering mucous membrane is normal.

In this condition, however, there is a possibility of an etiological irritation arising from a septic condition of the mucous membrane of the antrum.

There is an absence of the elastic sensation or egg-shell crackling obtained in dental cysts ; the growth is slower, more limited in extent, and less painful than in sarcoma, and its unilateral character and limitation serve to distinguish it from leontiasis ossea.

TREATMENT, when necessary, consists in reflecting the mucosa and gouging away the thickened bone. If this is carried out completely, recurrence does not take place.

VACUUM FRONTAL HEADACHE.

Under this title Sluder described a form of headache which results from closure of the inlet to the frontal sinus. As a result of this, the air in the sinus becomes absorbed, so that a diminished pressure is produced in the cavity and a secondary passive congestion of the lining membrane takes place. The thin bony floor of the frontal sinus becomes, in consequence, very sensitive to pressure. The maximum point of tenderness is elicited by pressure upon the thinnest part of the floor which lies medial and posterior to the attachment of the pulley of the superior oblique muscle of the eyeball (Ewing's sign). Owing to the close relation of the pulley to this thin area, the headache is intensified by the movements of the eyeballs in almost all acts of accommodation. Hence, aggravation of the headache from use of the eyes is an important diagnostic feature of the condition, especially in those cases in which there is an entire absence of nasal symptoms. The condition may be differentiated from supra-orbital and supratrochlear nerve neuralgia by the fact that these nerves lie lateral to the area described above. Moreover, in a neuralgic condition of these nerves, the tenderness elicited on pressure over them is less pronounced than that obtained by pressure upon Ewing's area in a case of vacuum headache.

The conditions in the nasal cavity which may produce the vacuum in the frontal sinus are in part anatomical, in part pathological. Thus, when the nasal cavity is narrowed by deflection of the septum, or when there exists an unusually narrow hiatus semilunaris, a superadded catarrhal swelling of the mucosa in the middle meatal region will lead to a closure of the frontal sinus inlet. In these cases the middle concha may present a normal appearance. On the other hand, the causative factor is more commonly a hyperplastic process of the covering mucous membrane and of the subjacent bone of the middle concha and anterior ethmoidal cell region, a condition which may be recognized by the presence of œdema or even polypus formation, and which results from a chronic non-suppurative catarrhal process.

TREATMENT should consist in the application of remedies which will diminish the local œdema, or, failing relief by such agents, in the removal of the redundant tissues. Nitrate of silver (in a 2 per cent solution) may be applied twice or thrice weekly to the œdematous mucosa by means of a probe dressed with cotton-wool. If cure of the headache is

not obtained in this way, dislocation of the middle concha towards the middle line may be tried. Should this procedure fail, removal of the anterior two-thirds or more of the middle concha should be practised, so as to open up the pathway to the frontal sinus. If the whole area of the bone which is undergoing hyperplastic changes be thus removed, the prognosis is good and the cure of the headache will be permanent. Recurrence may, however, take place if the pathological process continues and involves such parts as the uncinate process and the wall of the bulla ethmoidalis.

TUBERCULOSIS OF THE SINUSES.

Tuberculous affections of the sinuses are rare, either as primary or secondary infections. Two or three cases of apparently primary tubercle of the maxillary sinus are on record. Tubercle bacilli have been found in the antral discharge of patients suffering from pulmonary tuberculosis, but the clinical features may differ in no respect from those of an ordinary pyogenic infection. Tuberculous disease of the nasal or buccal cavities may extend and secondarily invade the sinuses, the antral cavity being that most commonly involved.

MALIGNANT DISEASE AFFECTING THE SINUSES.

Malignant tumours developing primarily in the nasal sinuses usually originate in the maxillary or ethmoidal cells. A. J. Wright has drawn attention to the usual association of malignant disease with chronic nasal suppuration and to the possibility that the latter is a factor in the production of the growth. In many cases, however, when the operation area is exposed, it may be difficult to determine the exact seat of origin of the growth, as cases come under observation in the later stages when the disease is considerably advanced and has extended from one cavity to another. Both carcinomata and sarcomata are met with. The prognosis varies, some tumours being much more malignant than others and liable to rapid local recurrence. Secondary glandular involvement is rare.

The symptoms and signs which should raise the suspicion of malignant disease in this situation are: pain, often severe in character, progressive nasal obstruction, discharge from the nose, recurring epistaxis, and sometimes epiphora. When the tumour originates in the antrum, swelling of the cheek occurs, either infra-orbital in position or occupying the canine fossa, while sooner or later displacement of the eyeball is observed. The association of this phenomenon with severe pain and swelling of the cheek is strongly presumptive of malignant tumour.

Carcinoma of the antrum of late has been shown by statistics to be on the increase. Its origin is usually in the upper inner posterior part of the antrum. Apart from the swelling of the face and occasional pain, its symptoms vary very little from a chronic antral suppuration. Its presence has often remained undetected until a radical operation has been performed for the chronic suppuration. Most authorities agree that a free opening of the antrum is desirable with preservation of as much

of the floor as possible. Radium needles are packed into the antrum ; the average dose is about 2000 radium hours. Following on this, deep X-ray therapy or radium-bomb therapy should be used over the affected antrum and ethmoidal cells. Recurrence usually takes place in the adjoining ethmoidal region.

Inoperable cases, on the other hand, are those arising primarily from the base of the skull and secondarily invading the air-sinuses ; also growths with extensive involvement of the pterygo-maxillary fossa ; tumours associated with persistent meningeal irritation ; and those in which the orbit is extensively implicated and where removal of the eyeball will not eradicate the disease.

Section III.

THE PHARYNX AND NASOPHARYNX.

DOUGLAS GUTHRIE and CHARLES E. SCOTT.

CHAPTER XIV.

ANATOMY.

The Pharynx (*Fig.* 56) extends from the base of the skull above, where it communicates in front with the nasal cavities, to the level of the sixth cervical vertebra below, where it becomes continuous with the œsophagus. The pharynx is about 5 inches in length and measures 1½ inches from side to side at its widest part, which is just above the entrance to the larynx. The wall of the pharynx consists of three layers, viz.: (1) An inner or lining layer of mucous membrane; (2) A middle or fibrous layer; and (3) An outer or muscular layer. Numerous mucous glands are to be found in the mucous membrane which entirely lines the pharynx and which is covered with stratified squamous epithelium, save in the nasopharynx, where the epithelium is of the columnar ciliated type. External to the lining mucosa is a firm fibrous envelope, the pharyngeal aponeurosis, which is thickest at its upper part, where it is closely attached to the base of the skull. The outer or muscular layer consists of the three constrictor muscles of the pharynx, which overlap one another from below upwards (*Plate VII*, B). The constrictor muscles arise from bones and cartilages in front and gain insertion, posteriorly, by joining their fellows in a median tendinous
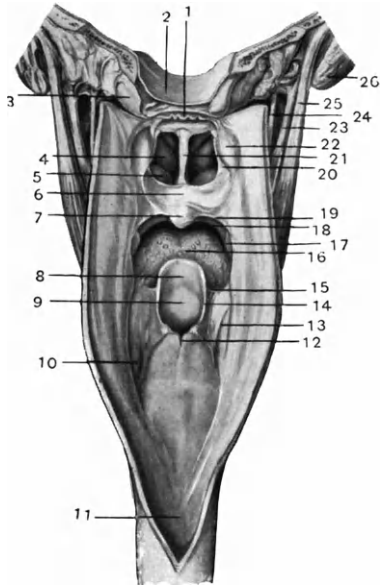
Fig. 56.—The pharynx, opened from behind. (1) Adenoids; (2) Clivus; (3) Occipital condyle; (4) Middle concha (turbinal); (5) Inferior concha (turbinal); (6) Velum of palate; (7) Uvula; (8) Epiglottis; (9) Cushion of epiglottis; (10) Pyriform sinus; (11) Œsophagus; (12) Inter-arytenoid notch; (13) Fold of laryngeal nerve; (14) Aryepiglottic fold; (15) Lateral glosso-epiglottidean fold; (16) Tongue; (17) Tonsil; (18) Glosso-palatine arch; (19) Pharyngo-palatine arch; (20) Auditory (Eustachian) tube; (21) Nasal septum; (22) Cartilage of Eustachian tube; (23) Stylohyoid muscle; (24) Hypoglossal nerve; (25) Digastric muscle; (26) Mastoid process.

raphé. For convenience of anatomical description, the pharynx is usually regarded as having three parts—the pars nasalis (nasopharynx), the pars oralis (oropharynx), and the pars laryngea (laryngopharynx) (*Fig.* 57). The pars nasalis lies above the soft palate and is described in a previous chapter (p. 11). The pars laryngea is situated behind the larynx and its upper part may be inspected by means of the laryngoscope. In length the laryngopharynx is equal to the combined lengths of nasopharynx and oropharynx. From a clinical standpoint it may be regarded as part of the larynx, and its structure is therefore described along with the anatomy of the larynx (p. 164). The pars oralis is that part of the pharynx which lies behind the mouth and may be seen on examination with the aid of a tongue depressor.

In this section the term 'pharynx' refers to the pars oralis alone. Its most prominent feature is the free edge of the soft palate forming the palatine arch, or isthmus faucium, under which the cavity of the mouth communicates with that of the pharynx. From the centre of this arch hangs the uvula, while to either side pass two crescentic folds of mucous membrane, the palatine arches (pillars of the fauces). The glosso-palatine arch (anterior pillar), which contains the palatoglossus muscle, passes downwards to the tongue, while the pharyngo-palatine arch (posterior pillar), supported by the palatopharyngeus muscle, merges into the lateral wall of the pharynx. The floor of the palatine archway is formed by the upper surface of the tongue.
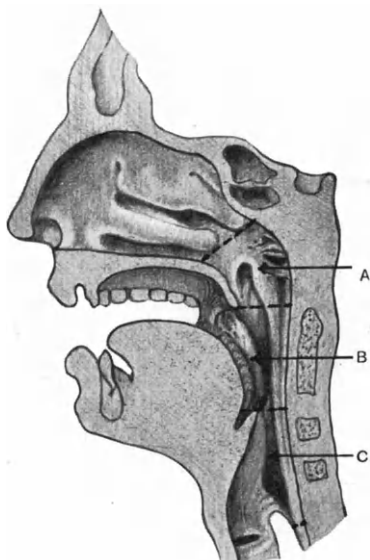
Fig. 57.—Sagittal section showing lateral wall and anatomical divisions of pharynx. (A) Pars nasalis (nasopharynx); (B) Pars oralis (oropharynx); (C) Pars laryngea (laryngopharynx).

The posterior wall of the oropharynx lies in front of the third cervical vertebra and, when the soft palate is raised, also in front of the lower part of the body of the axis vertebra (Quain).

THE TONSILS.

The two tonsils, more correctly known as the faucial or palatine tonsils, to distinguish them from the pharyngeal tonsil or 'adenoid' which has been already described on page 11, are masses of lymphoid tissue situated one in each lateral wall of the pharynx, occupying the interval between the anterior and posterior palatine arches, or pillars, of the fauces. The tonsil is developed in the region of the second visceral cleft of the embryo which, persisting unclosed at its inner extremity, becomes surrounded

PLATE VII

ANATOMY OF THE PHARYNX
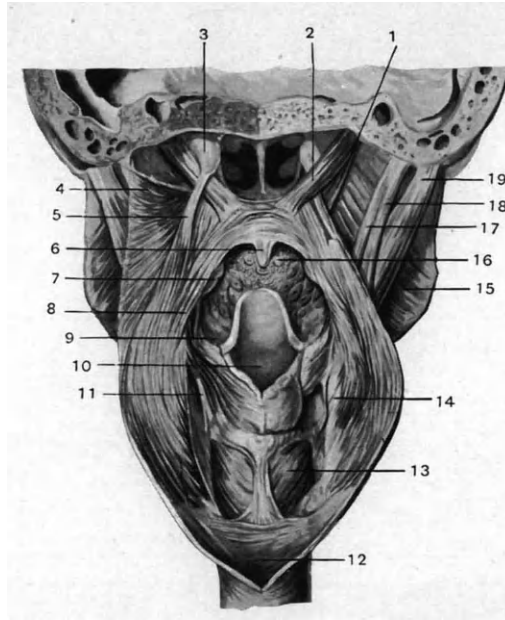
Fig. A.—The pharynx, dissected from behind, to show muscles, etc. (1) Tensor of palate; (2) Levator palati: (3) Cartilage of Eustachian tube; (4) Superior constrictor; (5) Salpingopharyngeus; (6) Uvula; (7) Palatine tonsil; (8) Palatopharyngeus; (9) Pharyngo-epiglottic fold; (10) Upper aperture of larynx: (11) Superior laryngeal nerve; (12) Œsophagus; (13) Posterior crico-arytenoid; (14) Posterior border of thyreoid cartilage; (15) Internal pterygoid; (16) Tongue; (17) Stylopharyngeus; (18) Stylohyoid; (19) Digastric.
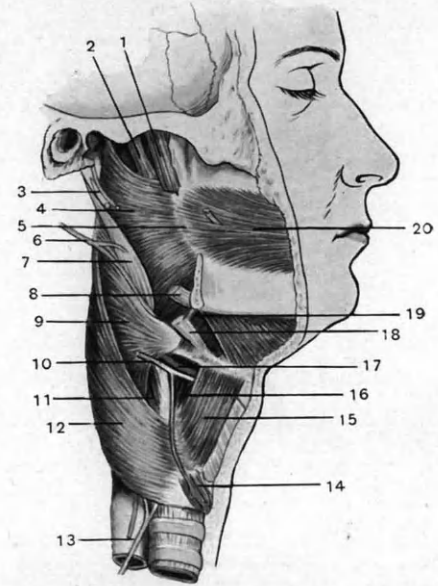
Fig. B.—Lateral aspect of the pharynx. (1) Tensor of palate; (2) Levator palati; (3) Stylo-hyoid ligament; (4) Superior constrictor; (5) Pterygomaxillary ligament; (6) Glossopharyngeal nerve; (7) Stylopharyngeus; (8) Styloglossus; (9) Middle constrictor; (10) Superior laryngeal nerve; (11) Stylopharyngeus; (12) Inferior constrictor; (13) Recurrent laryngeal nerve; (14) Crico-thyreoid; (15) Thyreo-hyoid; (16) External laryngeal nerve; (17) Superior laryngeal artery; (18) Stylo-hyoid; (19) Hyoglossus; (20) Buccinator.

by lymphoid tissue and ultimately forms the supratonsillar fossa or recess (*vide infra*).

Usually described as almond-shaped, with the long axis vertical, the tonsil varies so greatly in shape and size that it is a difficult matter to describe the 'normal' tonsil.

As a rule about one-third of the tonsil is embedded in the wall of the pharynx, but variations are considerable. In children of four to six years of age there occurs that slight physiological enlargement which so frequently becomes pathological. After puberty the tonsils become smaller, and in old age they may atrophy.

The free surface of the tonsil is covered by mucous membrane and dotted by depressions, which are the openings of the crypts which ramify within the tonsil and may extend as far as its deep surface, constituting excellent culture tubes for micro-organisms.

Occupying the upper pole of the tonsil is the largest crypt, already mentioned as the supratonsillar fossa or recess, but

Fig. 58.—Anatomy of the tonsils. (A) Supratonsillar fossa ; (B) Buried portion of tonsil.

better described as the intratonsillar recess, as it is within, and not above, the tonsil (*Fig. 58*).

The deep surface of the tonsil is bounded by a layer of firm fibrous tissue, the capsule, and between this and the superior constrictor muscle there is some loose areolar tissue, which during the operation of tonsillectomy forms a natural plane of cleavage in the upper part, although the lower pole of the tonsil is more densely adherent to the subjacent muscular tissues. A fold of mucous membrane, the plica semilunaris, unites the palatine arches at their junction with the soft palate and forms the medial wall of the tonsillar recess, whilst another fold, of varying extent, the plica triangularis, may cover and even hide the anterior surface of the tonsil, and may surround the lower pole of the tonsil like a sling (*Fig. 59*).

Fig. 59.—To show : (A) Projecting tonsil ; (B) Buried tonsil.

The lower pole of the tonsil may be prolonged downwards over the tongue, and may here become continuous with the lymphoid tissue on the dorsum of the tongue just in front of the epiglottis, the so-called lingual tonsil.

The blood-supply of the tonsil is derived from branches of the external carotid artery, namely, the tonsillar branches of the lingual, facial and ascending pharyngeal arteries, and the descending palatine branch of the internal maxillary artery. Most of those tonsillar arteries pierce

the capsule to enter the lower half of the tonsil, but the last-named branch enters the upper pole of the tonsil behind the anterior palatine arch, and may constitute a source of hæmorrhage which is apt to escape notice.

The veins from the tonsil unite to form the tonsillar plexus lateral to the capsule, and this plexus is intimately connected with the plexus of veins which surrounds the pharynx. The pharyngeal plexus in turn communicates with the internal jugular vein, which also receives blood from the cavernous sinus, by way of the inferior petrosal sinus, a fact which explains the occasional occurrence of cavernous sinus thrombosis as a sequel to septic infections of the pharynx or tonsils. Tortuosity of the internal carotid artery, causing a prominence on the pharyngeal wall, has been frequently noted. Normally, however, this vessel lies from ¾ to 1 in. distant from the lateral surface of the tonsil (see Fig. 60). The lymphatics which drain the tonsil enter the superior deep cervical glands. A gland which lies just above the common facial vein, as it joins the internal jugular, is prone to enlargement in infection of the tonsil, and is then palpable

Fig. 60.—Horizontal section of the face, showing relation of the carotid arteries to the tonsils. (1) Common facial vein; (2) Internal jugular vein; (3) Internal carotid artery; (4) Sympathetic nerve; (5) Vagus nerve; (6) Styloid process; (7) External carotid artery; (8) Inferior dental artery and nerve; (9) Tonsil; (10) Lingual nerve; (11) Lower jaw; (12) Buccinator muscle; (13) Masseter muscle; (14) External pterygoid muscle; (15) Styloglossus muscle; (16) Parotid gland; (17) Sternomastoid muscle; (18) Lymphatic gland.

just behind the angle of the jaw. In the posterior wall of the pharynx, between the superior constrictor muscle and the prevertebral muscles, lie a few lymphatic glands which may suppurate and give rise to one form of retropharyngeal abscess (p. 119).

THE LYMPHOID TISSUES OF THE PHARYNX AND WALDEYER'S RING.

As has been mentioned, lymphoid tissue is present on the posterior (pharyngeal) surface of the tongue, sometimes to such an extent as to warrant the use of the term 'lingual tonsil'. It is liable to infection and enlargement and may share in affections of the palatine tonsil. Behind each posterior pillar is a vertical strip of lymphoid tissue, the lateral band, which undergoes enlargement in chronic pharyngitis. Lymphoid tissue is also present at the entrance to the auditory (Eustachian) tube on either side. It will therefore be seen that the lymphoid structures of the pharynx are arranged in the form of a ring, which is known as 'Waldeyer's lymphatic ring' (Fig. 61). In addition, discrete lymphoid follicles are to be found on the posterior pharyngeal

wall.   Each of the structures composing the ring is drained by efferent
lymphatic vessels into the lymphatic glands which, as the diagram
shows, form an outer line of defence against infection.
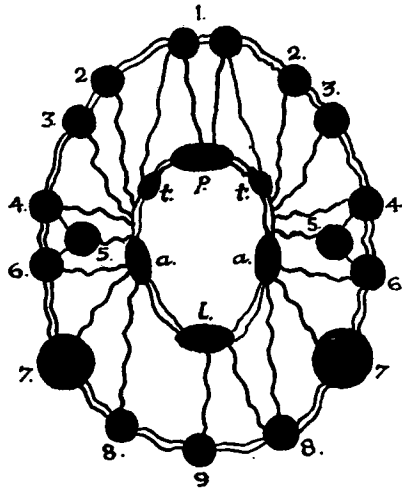
Fig. 61.—Waldeyer's lymphatic ring and its connections. (1) Retro-
pharyngeal, (2) Styloid, (3) Lateral pharyngeal, (4) Behind sternomastoid,
(5) Bifurcation, (6) In front of sternomastoid, (7) Angle of jaw, (8)
Hyoid, (9) Subhyoid glands. (*p*) Pharyngeal, (*t*) Tubal, (*a*) Faucial, (*l*)
Lingual tonsils.

THE FUNCTION OF THE TONSILS.

The function of the tonsils is still a subject of much controversy.   By
some they are regarded merely as lymphatic glands, concerned in the
production of lymphocytes.   There is little evidence to support the view
that the tonsil is a gland of internal secretion.   It appears probable that
the chief purpose of the tonsil is to promote immunity to infection during
early life.   The tonsillar crypts, becoming filled with bacteria that have
gained access by the mouth, act as culture tubes for the production of
vaccines which are conveyed in small doses by the lymphatics to the
fixed cells of the body.   In this manner the cells are stimulated to pro-
duce antibodies and immunity is gradually established.   Kenelm Digby
has shown, in his work on *Immunity in Health*, that the tonsils, in common
with other subepithelial lymphatic glands (Peyer's patches, appendix
vermiformis, etc.), are not only the nurseries but also the training
schools for lymphocytes, and that by their autovaccinating activities
they confer upon their owner, especially during childhood, immunity
against myriads of harmful bacteria.

CHAPTER XV.

METHOD OF EXAMINATION.

A VIEW of the pharynx, sufficient for ordinary purposes, can be obtained by daylight without the aid of a mirror ; but it is certainly not possible to make a thorough examination in this way ; it is accordingly advisable to make use of the forehead reflector and good artificial light (*Fig.* 62).

After the light has been adjusted and focused, the patient is asked to open his mouth. The use of a simple form of tongue depressor such
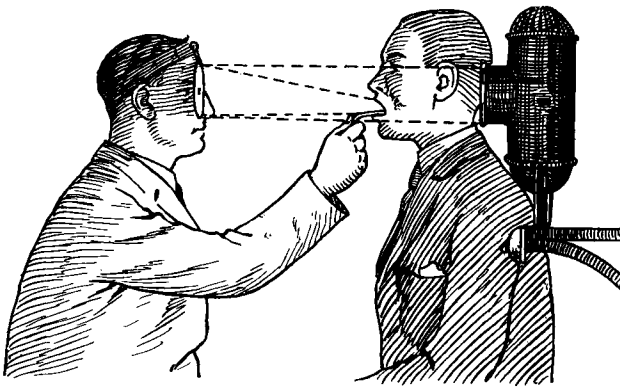
Fig. 62.—Examination of pharynx by reflected light.

as Lack's will facilitate the examination. To obtain a good view of the pharynx, the depressor is introduced so that its tip reaches just beyond the highest part of the dorsum of the tongue, and the instrument is then pressed gently downwards and slightly forwards, the patient continuing to breathe quietly by the mouth. The mucous membrane of the buccal cavity should be inspected first ; to do this thoroughly the tongue spatula is used to draw the cheeks away from the upper and lower jaws in turn ; the inner aspect of the lips and the under surface of the tongue should also be looked at. In this way the whole mucous lining of the mouth can be examined rapidly, and any abnormality will be detected at once. It is essential to carry out this inspection when there is any suspicion of secondary syphilis, as the delicate mucous patches character-istic of this disease easily escape notice.

The condition of the tongue must be carefully noted, having regard to its mobility as well as to its appearance. The sides of the tongue and the angle between the palatine arches and the tongue should be scrutinized, as malignant disease in this situation is not uncommon. The teeth and gums should be inspected for evidence of dental caries or sepsis. Dentures should therefore be removed to permit of examination of the underlying parts ; for in numerous patients, especially of the hospital class, these plates are fitted over carious roots. The irritation of a badly-fitting dental plate is a common cause of sore throat, a possibility which must always be borne in mind. The relationship of carious teeth to maxillary sinus suppuration, and of pyorrhœa alveolaris to tonsillitis, will serve to illustrate the importance of an examination of the teeth and gums.

Attention may now be directed to the soft palate, where, in particular, anæmia should be looked for. The distance of the velum palati from the posterior wall of the pharynx is sometimes a factor of importance. In singers the space should be large, as this gives more room for resonance, and the quality of the voice is thereby improved. When the function of the soft palate is impaired, speech becomes nasalized, the defect known as rhinolalia. The only English speech sounds pronounced with an open nasopharynx are *m*, *n*, and *ng*. For all other sounds the palate is raised so as to close the nasopharynx, although the degree of closure may vary. The action of the palate may be studied while the patient says *ah*. A useful test of function consists in the repetition, in sequence, of the sounds *ah* and *ee*, first with open nostrils and then with the nose held closed ; normally, no difference is apparent, but in rhinolalia aperta the sounds are more 'nasal' in character when the nose is closed. This is the A-1 test of Gutzmann.

Rhinolalia aperta is the term applied to the nasal type of speech caused by failure of the soft palate to close the nasopharynx, the variety of speech defect exhibited by cases of cleft palate. It may appear as a temporary sequel to the removal of adenoids. When the nasal speech is caused by nasal obstruction, for example, by adenoids, it is known as *rhinolalia clausa*. When rhinolalia aperta is due to cleft palate it is easy to diagnose, but some difficulty may be presented by the two varieties of *congenital insufficiency of the palate* which have been described by Brown Kelly. In the first, known as *submucous cleft palate*, the mucosa is intact but the mesoblastic structures, bone and muscle, have failed to unite. The posterior edge of the hard palate is notched or cleft, both hard and soft parts of the palate are shorter than normal, and muscular movement is ineffective.

In the second variety, *congenital muscular insufficiency of the palate*, there is simply imperfect action, without notching of the hard palate or shortening of the hard or soft palate. In both varieties the chief symptom is rhinolalia aperta, which dates from the time the patient began to speak. The same open nasal speech may reveal the existence of an unsuspected *post-diphtheritic paralysis*, the true nature of the throat affection recently complained of by the child having been overlooked, while the subsequent paralysis alone gives the clue to the correct diagnosis.

It is necessary at times to test the tactile sensibility of the soft palate ; to do so, it should be touched with a probe, a comparison being made between the two sides.

The pharyngeal reflex is increased in heavy smokers and in sufferers from tuberculosis ; it is diminished in infancy and old age and in certain nervous affections, such as hysteria, bulbar paralysis, etc.

A careful inspection of the tonsils should be made. In the adult they should not project beyond the anterior pillars of the fauces, nor should the latter be adherent to the tonsil. The mouth of the tonsillar recess, which is found in the upper part (already described) of the tonsil, should also be examined. The clinical importance of this cavity, first recognized by Paterson and Killian, has now been fully admitted, as it frequently forms the starting-point of a peritonsillar abscess. The fossa may be investigated by a probe or a strabismus hook, while its contents, e.g., cheesy pus, may be evacuated by pressure on the anterior pillar with the point of a tongue depressor (*Fig.* 63), or with a tonsil probe such as that designed by Tilley.

The state of the mucosa of the posterior pharyngeal wall should be noted. A dry, atrophic mucous membrane may indicate the existence of ozæna or of chronic suppuration of the posterior paranasal sinuses. Enlarged lymphoid nodules and dilated venules accompany chronic hypertrophic pharyngitis, and the region is a very favourite situation of syphilitic ulceration. An appearance suggesting an enlarged gland, or even an abscess, may be observed, especially in thin persons with long necks, if the head is turned to one or other side during the examination. The prominence then apparent behind the tonsil is merely a physiological phenomenon, and is really due to the more forward position of the cervical vertebræ resulting from the rotation of the head (Douglas Guthrie).

Fig. 63.—Examination of the tonsil on the right side. The anterior pillar (palatine wall) has been drawn aside by a second tongue depressor so as to expose the tonsil.

When abnormal conditions have been found in the pharynx, the state of the cervical lymphatic glands should be investigated, as frequently this is of no little importance in modifying prognosis and treatment. The converse is equally true ; in every case of cervical glandular enlargement a careful examination of the mucous membrane of the fauces and oropharynx should be made, and, if no pathological condition be detected there, the nose, nasopharynx and laryngopharynx should also be examined.

Congenital abnormalities of the pharynx are not infrequent ; bifid uvula is perhaps the commonest. More rarely, perforation of the anterior pillars is seen, and in such cases their symmetry and the absence of scarring will prevent a mistaken diagnosis of syphilis. Large pulsating

vessels are occasionally seen in the posterior pharyngeal wall, and cutting operations in their neighbourhood should be avoided.

Some children refuse to allow their throats to be examined peaceably ; it then becomes necessary to use some means of restraint. The most satisfactory way to do this without hurting the child is to have it held according to the method adopted in some Continental clinics for removal

Fig. 64.— Holding a refractory child.

of adenoids (*Fig.* 64). A nurse takes the child on one knee, imprisoning his legs with her own ; she then places one arm round his body, pinioning his arms, while with her other arm and hand she steadies his head against her shoulder. The surgeon holds the nose of the patient until the latter is forced to take a breath through the mouth ; the spatula is then introduced and a view of the parts is obtained.

CHAPTER XVI.

ACUTE INFLAMMATIONS OF THE PHARYNX.

ACUTE PHARYNGITIS.

THIS is the commonest variety of sore throat, and most readers have had personal experience of it. It is more liable to occur in autumn and winter than in summer; it is common in measles, scarlet fever, small-pox, typhoid and influenza, and it is a frequent early manifestation in syphilis. It may also occur after the administration of certain drugs, such as iodide of potassium, mercury and arsenic; while gouty or rheumatic persons, as well as those who lead a sedentary life, are more liable to be attacked than other individuals. Decayed teeth, pyorrhœa alveolaris and nasal obstruction are also predisposing factors which must not be overlooked.

SYMPTOMS.—An attack begins with a feeling of chilliness, slight rise of temperature, headache, pains in the limbs and back, and a sensation of rawness in the throat which sometimes amounts to actual pain. Cough may be present; there is a varying degree of pain on swallowing and, if the process extends to the larynx, the voice becomes hoarse. On examining the throat there is seen a marked congestion of the mucosa, accompanied by some swelling which gives a succulent appearance to the parts. The tonsils, the palatine arches (anterior and posterior pillars of the fauces), the soft palate and the posterior wall of the pharynx may all share in the congestion, becoming dark red or even purple in colour, while the uvula may be swollen and œdematous.

DIAGNOSIS.—As a rule this presents no difficulty, but in children one must suspect the onset of measles or scarlet fever, and examine the mouth carefully for Koplik's spots and the skin for any trace of rash. In adults, syphilis must not be forgotten.

TREATMENT.—Many people do not undergo any treatment, but if advice is sought at the beginning of the attack, the patient should be recommended to retire to bed early after a very hot bath and to take 10 or 15 gr. of aspirin. The bowels should be well opened by a few grains of calomel, followed by a saline. The administration of fractional doses of calomel, viz., $\frac{1}{8}$ or $\frac{1}{6}$ gr. every half-hour until two or three grains have been taken, is said to be more efficacious than a single full dose. The saline aperient should be an effervescing preparation, such as seidlitz powder or effervescing sulphate of soda. Morell Mackenzie recommended a full dose of tinct. opii, taken early in the day so as to secure the stimulating, rather than the soporific, effect of the drug. Teaspoonful doses of bicarbonate of soda, well diluted, a minimal diet, with liberal potations

of orange-juice, and small doses of tincture of iodine, 1 min. in a tumblerful of water to be sipped frequently, are three methods of treatment which have been strongly advocated.

Local treatment is of less importance. The early application to the affected mucosa of a solution of silver nitrate, 60 gr. to 1 oz., will some-times abort the attack. This remedy must not, however, be entrusted to the patient. A teaspoonful of bicarbonate of soda in a tumblerful of hot water furnishes a soothing spray. The alkali dissolves the thick tenacious mucus and thus cleanses the inflamed surface. Gargles and throat paints are of little value, but in the later stages the use of lozenges containing menthol and red gum will hasten recovery.

Fig. 65.—The organisms of Vincent's angina.

VINCENT'S ANGINA.

This ulcerative lesion of the tonsil assumed a remarkable prevalence among soldiers during the war of 1914–18, and is of importance on account of its resemblance to other affections, such as diphtheria and syphilis. It is associated with the presence of two organisms, a fusiform bacillus and a spirochæte, which are found together in the lesions and may be demonstrated by means of dark-ground illumination or by negative staining with Indian ink or collargol (*Fig.* 65). It must also be borne in mind that cases have been reported in which Vincent's angina was found in combination with malignant disease, the Vincent's organisms having found a suitable nidus for their growth in a pre-existent malignant ulceration of the pharynx or tonsil. Both organisms are Gram-negative. The fusiform bacillus is a straight or bent rod, with tapering ends, and

always thickest at its centre. The spirochæte (*Sp. fetida* or *denticola*) resembles an eel or a whiplash, its undulating curves serving sharply to distinguish it from the close-coiled corkscrew spirals of *Sp. pallida*.

SYMPTOMS.—As a rule the ulceration affects one tonsil only ; but the gums and palate, and even the larynx, may be involved. Appearing first as a sloughy grey patch, the lesion soon ulcerates so as to form a ragged, deep excavation with a dirty-grey granular base which bleeds readily. If the membranous deposit is removed it re-forms and, although most cases recover in a week or ten days, it may persist for several weeks and in rare instances may spread widely and prove fatal. In some cases the cervical glands are enlarged. There may be slight rise of temperature, sore throat and dysphagia, but as a rule the constitutional symptoms are slight. There is a characteristic fœtor associated with the disease which may assist diagnosis. (*Plate IX*, 3, p. 128.)

DIAGNOSIS.—The diseases for which Vincent's angina may be readily mistaken are syphilis and diphtheria, and diagnosis will frequently depend on the bacteriological report. An immediate diagnosis may often be made by the simple expedient of film examination for Vincent's organisms. Tertiary syphilitic ulceration may closely simulate Vincent's angina, but the former is usually surrounded by a hyperæmic zone which is not seen in Vincent's angina. The Wassermann reaction is negative in Vincent's angina, but is of little value, as the disease may occur in a syphilitic subject, or Vincent's angina and syphilis may be associated together. In diphtheria, severe constitutional symptoms will usually be present.

TREATMENT.—This consists in the careful cleansing of the ulcerated surface with peroxide of hydrogen (10 vol.), followed by the application of some antiseptic such as tincture of iodine, methylene blue, or trichloracetic acid. The last-mentioned, carefully applied on the end of a probe, is perhaps the most efficacious. The direct application of salvarsan has also been recommended. Wingrave recommends 5 per cent alcoholic solution of trikresol. Perborate of soda, 2 drachms in a tumblerful of water, may be useful as a gargle (*see* Appendix). When the gums are affected, Dudley Buxton recommends the application to the ulcerated area of a mixture consisting of equal parts of liquor arsenicalis, vinum ipecacuanhæ and glycerin. In all cases the teeth must receive careful attention, as here may lurk the source of the infection.

<div align="center">DIPHTHERIA.</div>

It would be outside the scope of this book to give a full description of diphtheria, for it does not usually come under the specialist's notice, and it is fully discussed in works on general medicine. It is necessary, however, to make some remark on the diagnosis, as diphtheria must be distinguished from other inflammatory conditions met with in the throat.

The age of the patient is an important factor in diagnosis. Diphtheria is essentially a disease of the first ten years of life, occurring most frequently in the period from two to five years (Ker). When the nose and nasopharynx are affected there is a fœtid and often blood-stained discharge,

PLATE VIII

AFFECTIONS OF THE PHARYNX
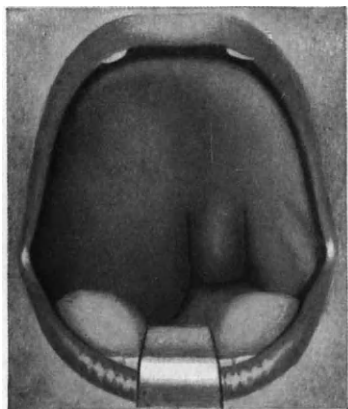
1. Acute peritonsillar abscess.
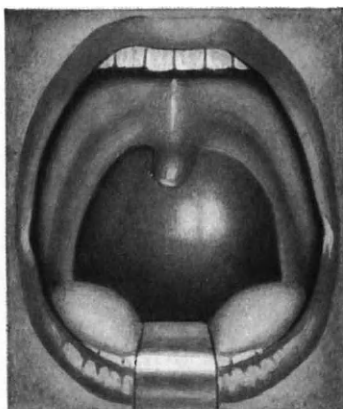
2. Acute retropharyngeal abscess.
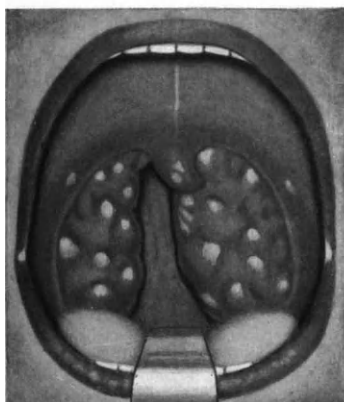
3. Acute lacunar tonsillitis.
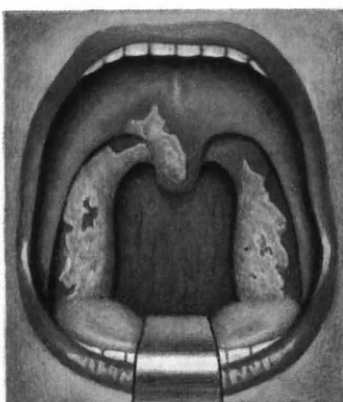
4. Diphtheria.

while extension to the larynx causes hoarseness and stridor and increases the gravity of the prognosis. In typical cases the disease is characterized by the formation of a false membrane, patches of which are seen on the tonsils and the soft palate, and sometimes also on the posterior wall of the pharynx (*Plate VIII*, 4). The colour of the membrane varies ; it is usually grey, but may be dead white, yellow, or dark brown. The colour of the fauces is dependent on the variety of the organisms present. Acute coccal infections may be associated with the diphtheritic infection. The membrane is firmly attached to the mucosa and, if forcibly removed, a bleeding surface is left on which it soon re-forms. Diphtheritic sore throat, however, is not always found associated with false membrane, and in these cases it is indistinguishable by the naked eye from simple sore throat. False membrane, moreover, may appear upon the fauces during the first week of scarlet fever and in some other conditions. In doubtful cases it may be useful to remember that diphtheria is gradual in onset, that the cervical glands are enlarged and tender, that the membrane is seldom limited to the tonsillar crypts but tends to spread over the tonsil and even on to the palate or uvula, and that vomiting and albuminuria are common accompaniments. In many cases, therefore, a diagnosis cannot be arrived at until a bacteriological examination has been made. It is unwise to wait for confirmation by the bacteriologist ; the patient should be isolated as soon as diphtheria is suspected and a prophylactic dose of antitoxic serum (2000 to 8000 units) should be given.

By means of the Schick reaction, it is now possible to ascertain the susceptibility or the immunity of a child to the diphtheria toxin, and this test may come to have an important bearing on the prevention of the disease. The problem of the diphtheria carrier cannot be discussed here. Suffice it to say that in many cases the organisms are located in the depths of the tonsil crypts, and as a rule nothing short of enucleation of the tonsil will put an end to the infection, although in certain cases vaccine therapy has proved useful.

Immunization against diphtheria has made progress recently in this country and in many of the larger cities the Public Health Authorities are providing the diphtheria toxoid.

HERPES.

This affection is rarely met with in the throat ; but the possibility of its occurrence must be borne in mind, for it is one of the conditions which may be mistaken for diphtheria. Groups of small vesicles appear, which are usually situated on the soft palate or palatine arches, and sometimes also on the posterior wall of the pharynx or around the upper aperture of the larynx. They soon become opalescent and burst, leaving white, round, shallow ulcers which may coalesce and give rise to an appearance resembling false membrane. The ulcers are surrounded by an area of redness and may cause considerable pain. There may be a herpetic eruption on the face or lips, or the mucous membrane lesions may occur alone. The condition is not serious and the treatment consists in the use of a mild antiseptic mouth-wash or pigment (*see* Appendix).

ACUTE SEPTIC INFLAMMATION OF THE PHARYNX.

Under this heading is described a group of conditions which have a common etiology (Semon) though they differ widely in their clinical aspects. The micro-organism usually present is the *Streptococcus pyogenes*; similar conditions may, however, be caused by other bacteria, such as *Staphylococcus aureus*, pneumococcus, *Bacillus coli communis*. The infecling agent appears to gain entrance to the tissues through intact mucosa, though probably, as in erysipelas, it enters by some minute break of the surface. We may differentiate clinically between : (*a*) Slight septic inflammation, commonly called hospital sore throat ; (*b*) Acute œdematous inflammation; (*c*) Acute suppuration or phlegmon; (*d*) Gangrenous sore throat.

SYMPTOMS.—The disease is especially prone to attack persons of feeble physique or those whose health has been impaired by alcohol, overwork, or insanitary surroundings. The symptoms and local appearances will vary, according as the case is one of hospital sore throat, which resembles a severe attack of acute tonsillitis, or of the serious and often fatal infection accompanied by cellulitis of the neck, known as Ludwig's angina.

The onset is usually sudden and in some cases the disease is ushered in by a rigor. The patient is seized with pain in the throat and has great difficulty in swallowing ; the temperature rises to its highest point at once, except in those cases in which the individual is immediately felled by the toxin, when there may be no pyrexia. The pulse is at first full and rapid, but soon becomes weak and thready ; after suppuration has begun there is profuse sweating. On examination, marked congestion and swelling are observed, and the uvula is œdematous and greatly thickened and elongated, giving the patient the sensation of a foreign body. If suppuration occurs it may be limited to the oropharynx, but the disease has a tendency to spread rapidly to the larynx ; the epiglottis then becomes enormously swollen and red, while the aryepiglottic folds also participate in the swelling, so that dyspnœa may supervene and necessitate immediate tracheotomy. (*See Fig.* 118, p. 178.)

In some instances the infection spreads to the submaxillary region, and causes a hard brawny swelling under the jaw (Ludwig's angina). Patches of gangrene may appear on the uvula or posterior wall of the pharynx, but this is very unusual. The lungs and serous membranes are liable to become secondarily affected, and pleurisy, pericarditis, or meningitis may manifest itself early in the disease.

PROGNOSIS.—The prognosis in suppurative pharyngitis is very grave ; heart failure may rapidly supervene—the purulent and gangrenous varieties usually end in early death, but the less serious non-suppurative cases may recover, even when the disease has spread to the lungs or serous membranes.

TREATMENT.—The patient must be kept in bed and fed on nutritious liquid diet of beef-tea, eggs, milk, etc., although, when dysphagia is severe, recourse must be had to nutrient enemata. A preliminary dose of calomel, gr. 3, is of value in the early stage. The mixture containing

the perchlorides of iron and of mercury (*see* Appendix) should be given. Antistreptococcic serum (scarlatinal) should be given as soon as possible, and repeated next day if required and followed by a non-sensitized vaccine. Local treatment of the throat should consist in the use of mild soothing applications, such as warm alkaline lotions used in the form of a spray or applied to the pharynx by syringing. The sucking of small pieces of ice has an anæsthetic and a sedative effect. Laryngeal œdema will call for special treatment. The frequent application of 1–5000 adrenalin may diminish the swelling, or scarification of the swollen tissues around the entrance of the larynx by means of Mackenzie's guarded laryngeal lancet may become necessary. On rare occasions tracheotomy will be required and should not be too long delayed, although the opening of a fresh path of infection is undesirable. When cellulitis of the neck has appeared, it should be treated by free incisions. In Ludwig's angina, incision from the chin to the hyoid bone may become necessary. Pus will seldom be encountered, the discharge being of a serous nature in most cases. Hot fomentations should be applied to the wounds, and may consist of 10 per cent aqueous solution of ichthyol, or of saturated solution of magnesium sulphate.

Convalescence, always slow and tedious, demands the use of tonics and a liberal diet, while a long holiday is advisable.

AGRANULOCYTIC ANGINA.

Agranulocytic angina or malignant neutropenia is a disease which has recently attracted much attention and it comes within the sphere of the laryngologist on account of the throat symptoms. It is commonest in women and is characterized by profound weakness and malaise, accompanied by slight fever and by superficial ulceration of the mouth and pharynx. The determining factor in diagnosis is the blood examination, which reveals a great diminution or even apparent absence of the neutrophilic granulocytes, so that the white count may be as low as 200, and is usually well under 2000. The important practical deduction is that every adult female patient, suffering from what appears to be an acute streptococcal sore throat and not responding to treatment, should have the blood carefully examined.

The disease is attended by a high mortality and the cause is as yet undetermined. Treatment by blood transfusion and by X rays has proved disappointing, but encouraging results have followed the intravenous administration of pentose nucleotide with the object of stimulating leucocytosis.

RETROPHARYNGEAL ABSCESS.

The two varieties of retropharyngeal abscess described in most textbooks are : (1) Acute retropharyngeal abscess, originating in the prevertebral lymphatic glands ; and (2) Chronic retropharyngeal abscess, the result of tuberculosis of the cervical vertebræ. The first variety is common, the second is at the present day relatively rare, but a third variety, ranking midway between them in order of frequency, is

(3) Chronic retropharyngeal abscess, due to tuberculous invasion of the prevertebral glands as an extension from tuberculosis of the deep cervical glands. The last-mentioned variety is easy to diagnose on account of the accompanying enlargement of glands in the neck, although owing to the gradual onset and absence of acute symptoms it is liable to be mistaken for adenoids. The second variety, coming to the notice of the surgeon with definite signs of tubercle of the vertebræ, should present no difficulty of diagnosis. The following remarks, therefore, apply to the first, and commonest variety, namely, acute retropharyngeal abscess.

ANATOMICAL DATA.—In order to understand the pathology of retropharyngeal abscess it is necessary to remember that the prevertebral fascia, stretching across the mid-line, separates the anterior visceral compartment of the neck, containing the trachea and œsophagus, from the posterior compartment which contains the prevertebral muscles and the cervical vertebræ and associated muscles. In front of the prevertebral fascia, and closely adherent to it in the mid-line, is the posterior wall of the pharynx, and between these two structures, on either side of the mid-line, there is a potential space, the space of Gilette, which contains the prevertebral or retropharyngeal lymphatic glands already mentioned. This group of glands is present in infancy but gradually disappears as the child grows, a fact which explains why retropharyngeal abscess is most common during the first year of life.

PATHOLOGY.—Infection of the deep cervical glands, known as the posterior carotid chain, may readily pass to the retropharyngeal group and give rise to abscess formation. In two-thirds of the cases there is obvious enlargement of the cervical glands and, as already mentioned, this enlargement may be of tuberculous nature. The most frequent cause of abscess, however, is the streptococcus, and this organism may be found in the pus in most cases. The tonsil is often regarded as the original source of infection, and the tonsils are enlarged in 80 per cent of cases of retropharyngeal abscess (Waugh). Otitic pharyngeal abscess may occur as a rare complication of middle ear suppuration (Dan McKenzie).

ETIOLOGY.—The condition is commoner in boys than in girls. It is rare in adults, and at least one-half of the patients are under one year of age.

SYMPTOMS.—Definite signs of retropharyngeal abscess may be few or wanting, and the disease is liable to be overlooked. Unlike adults, children seldom complain of sore throat, so that diagnosis is not easy. Indeed, the symptoms may be insufficient to attract attention until the abscess has so increased in size as to interfere with breathing or swallowing. The larynx, situated at a higher level in the child than in the adult, becomes partly obstructed at an early stage by the swelling (*Fig.* 66). The encroachment may be due simply to pressure, or to extension of the inflammation to the larynx, producing œdema laryngis. The important fact to be borne in mind is, that an illness in a child, associated with difficulty of respiration or deglutition, should lead to a careful examination of the throat. Difficulty of breathing is the leading symptom of retropharyngeal abscess. A croupy cough is sometimes present before dyspnœa sets in.

Bokai, who reported 204 cases, regards stiffness of the neck, the head being inclined towards the healthy side, as an important sign, while other writers have noted a characteristic throaty cry, resembling the quack of a duck.   When the abscess is at so high a level as to affect the posterior wall of the nasopharynx the symptoms suggest adenoids, and it is important to avoid this error in diagnosis.

DIAGNOSIS.—The swelling of the posterior pharyngeal wall, behind the tonsil and to one side of the median plane, is readily apparent on inspection (*Plate VIII*, 2, p. 116).   If the abscess extends upwards, it may cause the soft palate to project forward.   In examining, care must be taken to avoid turning the head to the side, as in this position the transverse process of the axis vertebra causes, in normal individuals, a bulging of the posterior pharyngeal wall.   Palpation is a valuable aid to diagnosis and may demonstrate the presence of fluctuation, although, on account of the thickness and firmness of the superimposed tissues, fluctuation is not always present.

TREATMENT.—As soon as diagnosis is established, the abscess should be opened through the mouth by a vertical incision.   When dealing with an abscess which is about to rupture, a long pair of sinus forceps or StClair Thomson's tonsillar forceps is to be preferred to a knife.   The forceps is plunged into the centre of the swelling and then opened widely. Care should be taken that none of the pus is aspirated into the lungs, a possible disaster which has led the majority of operators to discard

Fig. 66.—Acute retropharyngeal abscess in a child, age 14 months, who died on her way to hospital.   (*By kind permission of the* "*British Medical Journal.*")

general anæsthesia.   This is a sound practice, as the pain of the incision is momentary, and if the little patient is at once turned over on his face with the head low, the pus, which may be profuse in amount, escapes at once by the nose and mouth.   As a rule drainage is satisfactory, and rapid healing follows.

When the abscess is secondary to tuberculosis of the cervical vertebræ, it should be opened by incision along the posterior border of the sternomastoid.   Dissection is then carried between the carotid sheath and prevertebral muscles until the abscess is reached.

CHAPTER XVII.

CHRONIC INFLAMMATIONS OF THE PHARYNX.

CHRONIC PHARYNGITIS.

THE most common causes of the affection are, repeated attacks of acute pharyngitis; over-indulgence in tobacco, alcohol, or irritating articles of food; excessive or faulty use of the voice and prolonged exposure to a dusty atmosphere; while gouty or rheumatic individuals are especially liable to be attacked. The source of the trouble may frequently be traced to the nose or nasopharynx, where a search may reveal suppuration of paranasal air-sinuses, adenoids, or conchal hypertrophies.

For clinical purposes it is advisable to discuss the disease under three headings: (1) *Simple catarrhal pharyngitis*; (2) *Hypertrophic pharyngitis* (granular pharyngitis, clergyman's sore throat); (3) *Atrophic pharyngitis*, or *pharyngitis sicca*.

1. **Simple Catarrhal Pharyngitis.**—In this there are usually enlargement and congestion of the uvula and soft palate; the posterior wall of the pharynx may also be congested, and dilated veins may be seen coursing over its surface. This variety of pharyngitis is usually produced by exposure to dust, errors of diet, or over-smoking; indeed, nearly every smoker exhibits the condition in a greater or less degree. The symptoms generally complained of are a feeling of thickness in the fauces and a frequent desire to clear the throat.

TREATMENT.—This consists in correcting errors of diet, while the consumption of alcohol and tobacco should be very much restricted or entirely given up for a few weeks. The bowels should be kept open; a good aperient in these cases is a teaspoonful of Carlsbad salts taken before breakfast in a tumblerful of hot water. As a local application, Mandl's solution may be used, or an astringent pigment such as chloride of zinc 1 per cent, or nitrate of silver 2 to 5 per cent (*see* Appendix). A useful remedy consists in gargling each morning with alternate mouthfuls of hot water and of cold salt water. In very rare instances it may be advisable to snip off the end of the uvula with a pair of scissors; this procedure is, however, advisable only in quite exceptional circumstances, and should not be resorted to unless the uvula is sufficiently long to cause irritation by coming in contact with the back of the tongue.

2. **Hypertrophic Pharyngitis (Clergyman's Sore Throat).**—This form of pharyngitis is met with as a rule in persons who have to use their voices professionally, though a gouty or rheumatic diathesis also predisposes to the condition.

APPEARANCES.—Most cases exhibit great irritability of the throat, and the mere opening of the mouth may induce the patient to gag and

retch. Small nodules of lymphoid tissue are seen scattered over the posterior wall of the pharynx ; hence the condition is sometimes termed granular pharyngitis. A thick vertical band of lymphoid tissue may be seen on the lateral walls of the pharynx behind each posterior pillar of the fauces.

SYMPTOMS.—There is a constant desire to clear the throat, and a feeling as if there were a foreign body in it ; the chief complaint, however, is that the voice soon becomes tired and its carrying power is diminished, so that the patient finds it difficult to continue in the exercise of his profession.

TREATMENT.—The treatment of these cases is by no means easy, owing to difficulty in determining how far the symptoms are due to the objective changes found in the throat. Careful examination should be made for any underlying factor in the teeth, tonsils, larynx, or paranasal sinuses. In many cases faulty voice production, or forcing the voice, may be the chief cause of the condition, while the changes in the pharynx may be only secondary. It is important, therefore, before proceeding to local treatment, to inquire into the patient's method of using his voice in speaking in public. Pitching the voice too high, or an incorrect method of breathing, are common mistakes which throw a strain on the muscles of the pharynx or larynx ; in such cases the patient should be instructed to speak slowly and to allow pauses for inspiration, while the voice should be pitched in a lower key. It may be advisable to send the patient to a teacher of voice production for instruction. When these mistakes have been rectified, local treatment may be employed if it is then necessary. Granules may be destroyed with the cautery ; a flat burner at a dull-red heat should be used, and several may be cauterized at one sitting ; the throat should then be painted with equal parts of boroglyceride and glycerin. The cautery must, however, be used with discrimination as milder measures will often suffice. The throat should be frequently sprayed with a simple alkaline lotion containing salt, sod. bicarb., or borax, 5 gr. to the ounce, and this cleansing spray may be followed by the application of Mandl's paint. Painting the affected surfaces twice a week with solution of chloride of zinc, 20 gr. to the ounce, is also recommended. But it must never be forgotten that *the general treatment of the patient is often of greater importance than local applications*. Dyspepsia, anæmia, constipation, etc., should receive appropriate attention. If the patient is gouty or rheumatic, considerable benefit may result from a visit to some spa, such as Harrogate, Bath, or Bridge of Allan, where special facilities for local treatment are afforded.

3. **Atrophic Pharyngitis, or Pharyngitis Sicca.**—In this variety of chronic pharyngitis the etiology is obscure, though it is not uncommonly associated with Bright's disease and diabetes. The appearances, however, are quite distinctive.

SYMPTOMS.—The posterior wall of the pharynx presents a glazed surface on which a little dried secretion may be observed ; this change may be limited to the pharynx, or may extend to the larynx ; it is frequently met with in cases of atrophic rhinitis. Skillern regards such an appearance, when unilateral, as pathognomonic of nasal sinus

suppuration (sphenoidal or posterior ethmoidal). The nose, therefore, should be carefully examined in all cases. The chief symptom is dryness of the throat.

TREATMENT can be directed only towards the alleviation of the symptoms, as it is impossible to regenerate the atrophied structures of the mucosa. If crusts of dried mucus tend to form, these should be removed by syringing or spraying the throat with a warm alkaline lotion once or twice a day, and this preliminary toilet should be followed by the application of equal parts of ichthyol and lanoline, or of the French preparation known as gomenol, which is used as a 5 to 10 per cent solution in olive oil and applied by an atomizer. The internal administration of small doses of potassium iodide is often beneficial.

CHAPTER XVIII.

CHRONIC INFECTIVE CONDITIONS OF THE PHARYNX.

SYPHILIS.

THE customary classification of syphilitic lesions as primary, secondary and tertiary is only useful when one bears in mind that, clinically, no hard-and-fast lines can be drawn between these three stages.

Primary Syphilis, or chancre, is rare in the pharynx and, when it does occur, the tonsil is the part affected. It must be remembered that in at least 10 per cent of all cases of syphilis infection enters by some channel other than the genital organs. According to Fournier, 50 per cent of all extragenital chancres are on the lips, and as regards the remaining 50 per cent, the finger, the tongue and the tonsil are affected with equal frequency, each contributing about 17 per cent to the sum total. Chancre of the tonsil, though rare, is frequently diagnosed as some other condition, or escapes notice altogether. The important features are that it is unilateral, that it persists for several weeks, that the cervical glands are enlarged, and that the sore is of cartilaginous hardness when palpated with the gloved finger. Discovery of the *Sp. pallida* may assist diagnosis, but it is well to remember that other spirochætes [*Sp. buccalis*, *Sp. dentium*, *Sp. fetida* (Vincent), etc.] are commonly present in all ulcerative conditions of the mouth.

Secondary Syphilis.—This is more common and of infinitely greater importance. It may take the form of diffuse reddening or erythema of the palate and fauces, associated with some degree of enlargement of the tonsils, and is liable to be mistaken for simple acute pharyngitis. At a later stage the mucous patch or plaque is common. The mucous patch is the commonest of all syphilitic lesions and is certainly the most contagious. It may be found on any part of the mucous membrane of the mouth or pharynx, its favourite sites being, in order of frequency, the tonsil and faucial pillars, the tongue, and the inner aspect of the lips. As a rule the patch appears as a round or oval area, bluish-grey and faintly marked, projecting slightly from the surface and surrounded by a narrow zone of congestion. These areas vary in size from a pea to a sixpence ; they are often symmetrical and may be multiple. Sometimes they become confluent and cover a large area, as in a case seen by the writer, where the entire surface of the soft palate was involved. Ulceration may occasionally take place, but the typical mucous patch is an erosion rather than an actual ulcer. The terms 'opaline' and 'snail track' are often applied to it, but the usual appearance of the patch is dirty grey. The presence of enlarged glands and skin affections

may in some cases facilitate diagnosis. Prompt recognition of the mucous patch is highly important, as it teems with spirochætes and is a most fruitful source of infection.

Tertiary Syphilis.—The gumma is the typical lesion in this stage and seldom appears until after the first two years of the disease and, it may be, only after a lapse of many years. A hard, purplish swelling appears on the palate, on the posterior pharyngeal wall or, less frequently, on the tonsil. The hollow between the epiglottis and the tongue is a common site, liable to be overlooked because it is visible only with the aid of the laryngoscope. The swelling soon breaks down at its centre, rupturing on the surface and becoming an ulcer, with a greenish-yellow base, red indurated edges, and a 'punched-out' appearance which is often quite characteristic (*Fig.* 67).

POST-SYPHILITIC COMPLICATIONS.—The palate may be permanently perforated, with considerable destruction of tissue, and this is particularly prone to occur in hereditary syphilis, when tertiary phenomena appear about the age of puberty. Sometimes the soft palate becomes adherent to the posterior wall of the pharynx and causes, during the healing process, a degree of cicatricial stenosis unequalled by any other disease. In certain cases the nasopharynx may be almost entirely cut off from the mouth.
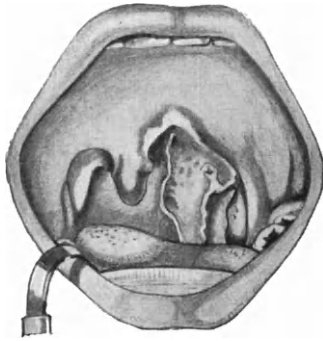
Fig. 67.—Tertiary syphilis of pharynx.

SYMPTOMS.—Secondary lesions usually cause only slight pain in the throat, although there may be difficulty in swallowing if ulceration has occurred. With tertiary ulcers pain is rare, the patient seeking advice on account of the nasal intonation of his speech, or because he is annoyed by the entry of fluid into the nose when eating.

DIAGNOSIS.—Discovery of *Sp. pallida* will assist the recognition of early stages of syphilis, especially of the primary sore. Mucous patches present quite a characteristic picture. It is during the later stages that difficulties of diagnosis are found. Tertiary ulceration of the tonsil resembles Vincent's angina. In both diseases the Wassermann reaction may be positive, but the combination of *Sp. fetida* and *B. fusiformis* characterizes Vincent's angina. Gummatous ulceration may also simulate carcinoma, though cancer is usually characterized by the more advanced age of the patient and by greater pain. Histological examination may decide the question.

Lupus has a finely nodular appearance and is generally found on the skin as well as on the mucous surface. The destructive effects of lupus are much more slowly attained than those of syphilis.

Too great stress should not be laid upon the result of the Wassermann test as an aid to diagnosis or as a controlling factor in treatment. Of prime importance is the fact that a negative reaction is of no value.

TREATMENT.—It is well to recognize, at the outset, that general measures are of infinitely greater importance than local applications. A combined treatment, consisting in the administration of mercury by the mouth and one or other of the arsenical compounds by intravenous injection, is perhaps the most generally adopted. The use of mercury by the mouth is so simple that it must remain the method of choice when the patient cannot be kept under constant supervision. The Hutchinson pill, containing 1 gr. each of grey powder and Dover's powder, is largely prescribed. During the administration of mercury the mouth must be kept vigorously cleansed, and tobacco and alcohol should be avoided. Treatment by intramuscular injections, though very efficacious, is seldom adopted in this country. The insoluble preparations of mercury, grey oil or calomel cream, are injected once a week ; the soluble salts may be injected daily. The intravenous use of cyanide of mercury (1 c.c. of a 1 per cent solution) has been found a valuable remedy.

Intravenous injections of salvarsan (606, arsenobenzol) and its substi- tute (914, neosalvarsan) are now very largely employed in the treatment of syphilis. These remedies, however, must be used just as persistently as mercury if permanent results are to be attained. Neosalvarsan is more easily administered than salvarsan, and may be given in concen- trated solution in 10 c.c. of cold distilled water.

Bismuth is now largely used in the treatment of syphilis. In potency it occupies a position between mercury and salvarsan, and it may be combined with the latter remedy (Lees).

Iodide of potassium does not in itself cure syphilis, but promotes the absorption of new connective tissue so that antisyphilitic remedies may more easily reach the spirochæte. It is of great value during the tertiary stage, between the courses of mercurial or arsenical treatment.

Local treatment, though less important, must not be neglected. Excision of the primary chancre of the tonsil is of little value, but equal parts of pure carbolic acid and tincture of iodine may be applied. Mucous patches should be cauterized with nitrate of silver, after cleans- ing with peroxide of hydrogen. In secondary lesions, as in all stages of buccal syphilis, an alkaline mouth-wash is acceptable to the patient. Another favourite application consists of equal parts of lotio nigra and saturated solution of chlorate of potash. The gummatous ulcer should be painted with chromic acid solution (10 gr. to the ounce), while large tertiary ulcers may be dressed with an insufflation of powdered calomel.

ACUTE MILIARY TUBERCULOSIS.

Acute tuberculosis of the pharynx is a rare complication of pulmonary tuberculosis. A number of minute grey or yellow tubercles appear on the fauces or palate, and these rapidly break down into shallow ulcers which spread superficially so as to form a large raw surface on the palate, faucial pillars and posterior pharyngeal wall, extending sometimes to the cheeks, tongue and epiglottis. The symptoms are pain on swallow- ing, salivation, throaty speech and rapid emaciation.

DIAGNOSIS.—The ulcer has no surrounding zone of congestion such as is seen in syphilis. Moreover, pain and dysphagia, generally absent in syphilis, are noteworthy features of miliary tuberculosis. The white membranous deposit on the ulcerated areas may at first suggest a diagnosis of diphtheria, but the Klebs-Löffler bacilli will be absent. In doubtful cases a portion of the edge of an ulcer should be removed for microscopical examination. Characteristic of tuberculosis is the pale, shallow ulcer, bathed in greyish mucopus, and having an indefinite and mouse-nibbled' edge.

PROGNOSIS is always grave, as the pulmonary disease has usually reached an advanced stage when the pharyngeal complication appears.

TREATMENT.—This can only be palliative, and must aim at relieving the pain, which is often so severe that the patient cannot even swallow his saliva. The ulcerated area should be kept clear by spraying with a warm alkaline lotion, and should then be powdered with orthoform, this treatment being repeated several times a day. When applied to the raw surface, orthoform acts as a local anæsthetic, and the effect lasts for several hours. Hypodermic injections of heroin and morphine may also be required.

LUPUS.

This slowly progressive and painless form of chronic tuberculosis is usually associated with lupus of the face and nose. It consists in the appearance on the palate and fauces and, less frequently on the uvula, of minute nodules, pinkish-yellow in colour, which resemble the well-known 'apple-jelly' nodules which are found in lupus of the skin. The eruption causes little inconvenience apart from a slight sensation of stiffness within the throat. The nodules have a tendency to break down and ulcerate and then to heal gradually, leaving radiating scars which are characteristic. Lupus generally begins before puberty and is commoner in females than in males. Diagnosis will present little difficulty if the disease affects the skin of the face as well as the pharyngeal mucosa. Syphilis has some resemblance to lupus, but is more rapidly and deeply destructive. The syphilitic ulcer is hyperæmic; the lupus ulcer is pale, and has a tendency to heal at one point while spreading at another (*Plate IX*, 2).

TREATMENT.—The best means of treating lupus of the pharynx is undoubtedly diathermy, but when the disease is extensive it may be necessary to employ curettage, under a general anæsthetic. The local application of ultra-violet light by the Finsen apparatus is well known and has stood the test of time, but the course of treatment must be long and persistent.

Even more important than local treatment is the general treatment of the sufferer from lupus. As in other forms of tuberculosis, a general sanatorium regime should be adopted, with abundance of fresh air, good food, ultra-violet light (natural or artificial), and graduated exercise. In view of the tendency of the disease to relapse after cure or apparent cure, the patients should be asked to report for examination at regular intervals, so that any recurrence may receive immediate attention.

PLATE IX

AFFECTIONS OF THE PHARYNX
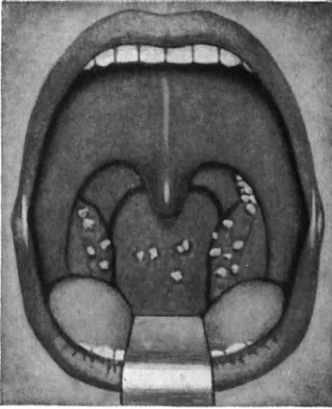
1. Keratosis pharyngis.
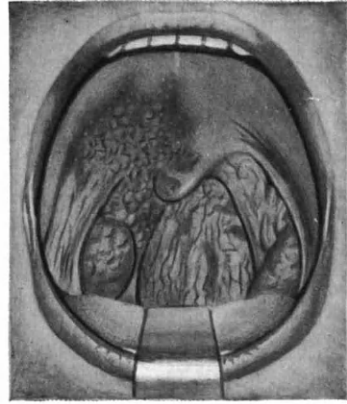
2. Lupus of soft palate and uvula.
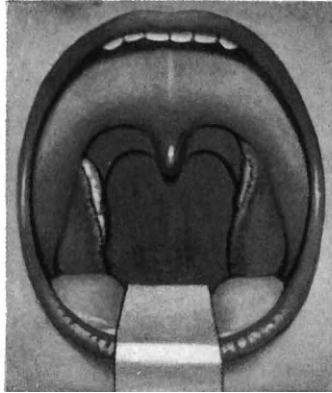
3. Vincent's angina.

Ionization has been successfully used, and good results have been reported from the employment of the electrocautery. The practitioner who does not possess electrical apparatus may achieve fair results with a bead of chromic acid fused on a probe, or by the application of acid nitrate of mercury (Adamson). Care must be taken to discover and treat all foci of disease in nose, larynx, etc. In the majority of cases (55 per cent according to Webber), the disease begins in the nose.

RHINOSCLEROMA AND LEPROSY.

These diseases are met with in the throat, but are rarely seen in this country. Scleroma is fairly common in Eastern Europe and in Asia, and usually affects the nose, though it may appear first in the pharynx. It appears in the form of painless, hard infiltrations, and is very resistant to treatment.

Leprosy is likewise rare in this country, and leprosy of the pharynx is usually secondary to cutaneous leprosy. The lesions are painless and may be anæsthetic. The characteristic bacilli will be found in the leprous and scleroma nodules.

CHRONIC HYPERPLASIA OF THE MUCOUS MEMBRANE.

This rare disease consists in a smooth, painless, and uniform thickening of the pharyngeal mucous membrane (Sefnon, Brown Kelly, Logan Turner). It may give rise to local discomfort and difficulty of swallowing. Sometimes the larynx is affected. Treatment is of no avail, but cases of spontaneous cure have been recorded.

AFFECTIONS OF THE TONGUE. (*See* Chapter XXIX, p. 225.)

CHAPTER XIX.

AFFECTIONS OF THE TONSILS.

ACUTE TONSILLITIS.

THERE are several varieties of acute inflammation of the tonsils ; they may be classified under the following heads : (1) *Catarrhal or parenchy-matous tonsillitis ;* (2) *Lacunar or follicular tonsillitis ;* (3) *Suppurative tonsillitis or peritonsillar abscess (quinsy).*

The first two cannot always be distinguished clinically and may therefore be described together.

Catarrhal, or Parenchymatous, and Lacunar, or Follicular, Tonsillitis.—The tonsils afford a portal of infection by which pathogenic organisms may gain access. Staphylococci or streptococci, or a combination of the two, are the bacteria generally present in acute tonsillitis ; but diphtheria bacilli and the pneumococcus may be met with, and it is important not to overlook the long-recognized fact that in many cases tonsillitis is a manifestation of rheumatism.

SYMPTOMS.—The symptoms are the same as in acute pharyngitis, but there is usually more constitutional disturbance, especially in the case of children. It is a curious fact, however, that children seldom complain of sore throat, so that tonsillitis may be overlooked in young patients. The temperature frequently rises to 104° or 105° F., the tongue is furred and the breath often offensive. There is usually diffi-culty in opening the mouth, a constant but much-dreaded desire to swallow, and extreme dysphagia, while pain radiating up to the ears is generally complained of. Constipation is common, and the urine is high-coloured and scanty. The appearances vary considerably ; in the catarrhal variety the inflammation involves the whole structure of the tonsil which becomes enlarged and appears red and swollen. In the lacunar form (*Plate VIII*, 3, p. 116) the inflammation is superficial and invades the crypts which fill with fibrin ; ulceration follows and involves the follicles (follicular tonsillitis), on which necrotic areas appear. On examination of such a case the tonsils are seen to be congested, slightly swollen, and studded with minute white points which become larger as the process extends, and which may coalesce. These can be easily wiped off, leaving no bleeding surface such as is seen in diphtheria.

DIAGNOSIS.—The possibility of some of these appearances being due to diphtheria, or to one of the septic forms of sore throat, must not be overlooked. Mistakes are most liable to be made in the lacunar form of tonsillitis and, if there is any reasonable doubt as to the nature of the disease, the proper course is to isolate the patient, take a swab from the throat, and treat the case as one of diphtheria until the bacteriological

examination clears up the diagnosis. Should the patient be a young child between the age of two and five years, it may be wise to administer antitoxic serum (4000 units). In diphtheria the attack commences more insidiously than in tonsillitis ; the temperature is not so high and vomiting and albuminuria are frequent. Lacunar or follicular tonsillitis is, however, undoubtedly infectious, so that the patient should, if possible, be isolated in any case, especially when there are children in the house. The sore throat of scarlet fever is often indistinguishable from a simple angina and, if the rash has not appeared, and the tongue does not present the typical strawberry appearance, the diagnosis may be impossible.

TREATMENT.—The patient should be sent to bed, and aspirin, 10 gr., may be given every three hours until the temperature falls. Tincture of aconite, in one-drop doses frequently repeated, was strongly recommended by Ringer, while Morell Mackenzie claimed to cure tonsillitis by guaiacum lozenges, 3 gr. every two hours, if given in the early stages. A poultice or hot fomentation to the neck is often comforting. The bowels should be opened by a dose of calomel at night, followed by a saline cathartic in the morning. The throat may be painted with glycerin of carbolic acid, or boroglyceride and glycerin, and when the breath is offensive a solution of peroxide of hydrogen (10 vol.) may be sprayed on the throat several times a day, after which the mouth should be washed out with boric lotion, a weak solution of permanganate of potash or some other mild antiseptic mouth-wash (see Appendix). Syringing the throat is often more effective than spraying or gargling, because the lotion can be used warmer and in larger quantity (StClair Thomson). A saturated solution of bicarbonate of soda employed in this way will dissolve the thick mucus which clings to the affected parts. It is sometimes possible to check an attack of tonsillitis by the application of a strong solution of silver nitrate to the surface of the tonsil. A dressed probe is used for this purpose and its point may be introduced into the larger crypts. Needless to say, this treatment can be carried out only by the medical attendant.

Peritonsillar Abscess (Quinsy).—This consists in suppuration outside the capsule of the tonsil situated, in the vast majority of cases, in the tissues of the soft palate above the tonsil. The route of infection appears to be by way of the supratonsillar fossa and there is no apparent relation between the size of the tonsil and the occurrence of a quinsy. Persons with small, ragged, unhealthy-looking tonsils are said to be more liable to abscess development. Adhesions between the tonsil and the plica semilunaris, the result of repeated attacks of tonsillitis, and islands of tonsillar tissue, the result of incomplete removal of the upper pole of the tonsil, tend to obliterate the supratonsillar fossa and predispose to abscess formation. As a rule the abscess is unilateral, but it is not uncommon for the opposite side to become affected a few days after its neighbour. The affection is rare in children, is commonest in adult males, and is said to exhibit an hereditary tendency.

SYMPTOMS.—The attack commences in the same way as do the other forms of tonsillitis, but the symptoms are more severe. The patient looks ill and wears an anxious expression ; the temperature may rise to

103° or 104° ; the onset may be signalized by shivering or a definite rigor ; and pain of a severe stabbing nature is felt in the tonsillar region, radiating to the ear and downwards to the neck.   Swallowing is so painful that saliva dribbles from the mouth, while the presence of swelling and secretion in the throat imparts to the speech a thick, muffled tone. Examination may be difficult, as the patient can open his jaws only to a slight extent ; but under good illumination it will be seen that on the affected side the palate is congested and bulging, the uvula, which is often much swollen and œdematous, being pushed across towards the opposite side (*Plate VIII*, 1, p. 116).   The tonsil may be almost hidden from view, but is frequently coated with a layer of mucopus which may extend over the abscess area. The cervical glands on the affected side are enlarged and tender.   If not relieved surgically the abscess will burst spontaneously in a week or ten days.

Fig. 68.—Evacuation of peritonsillar abscess through the palate by StClair Thomson's forceps.

PROGNOSIS is good and, although œdema of the larynx is an occasional complication, tracheotomy is seldom, if ever, required.

TREATMENT.—The medicinal measures as already described for other forms of tonsillitis should be adopted. Small doses of calomel, $\frac{1}{8}$ gr. every half-hour up to 2 gr., have been said to check the formation of peritonsillar abscess. Large doses of antistreptococcic serum (scarlatinal) have also been recommended. In most cases no relief will follow until the abscess has been opened, and this should be done early.   Pus is usually formed by the third or fourth day.   A long narrow bistoury may be used, bound with adhesive plaster so as to leave exposed half an inch of the extremity of the blade, but a better instrument for the purpose is the long bayonet-shaped sinus forceps recommended by StClair Thomson.   The point of entry in the palate should be above a horizontal line drawn through the base of the uvula and lateral to a vertical line along the anterior pillar of the fauces (*Fig.* 68).

Fig. 69.—Evacuation of peritonsillar abscess through the tonsillar recess.

The forceps are pushed suddenly and forcibly backwards into the abscess and immediately opened widely so as to evacuate the pus freely.   Local
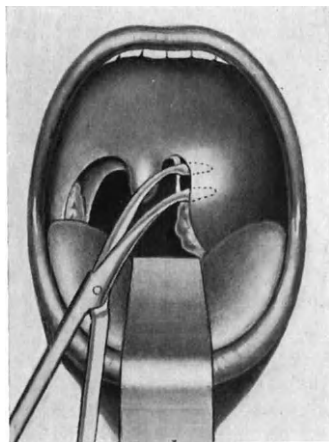
anæsthesia is of little value in the procedure, but the great relief afforded will be at once appreciated by the patient and rapid recovery follows. The method preferred by some consists in the evacuation of an abscess through the tonsillar recess by curved, sharp-pointed forceps. The abscess cavity is thus drained at its most dependent part, and the opening is less liable to close prematurely. This route of approach is indicated in *Fig.* 69. It has recently been suggested that the tonsil, or at least its upper pole, should be enucleated at the same time as the abscess is opened. In any case it is sound practice to advise enucleation of the tonsil after an attack of quinsy, so as to get rid of the septic focus and to obviate recurrence. Rapid improvement follows evacuation of the abscess, and this may be assisted by syringing the throat frequently with a warm solution of bicarbonate of soda. It may be necessary to introduce forceps into the opening which has been made, if there is any doubt as to the freedom of drainage.

CHRONIC INFLAMMATION OF THE TONSILS.

'Chronic inflammation of the tonsils may be divided into two groups : (1) *Chronic enlargement or chronic parenchymatous tonsillitis :* (2) *Chronic lacunar tonsillitis.*

1. **Chronic Enlargement of the Tonsils,** though it may occur in adults, is found chiefly in children between the ages of four and fifteen years. In the majority of cases, it is associated with hypertrophy of the naso-pharyngeal tonsil, commonly called 'adenoids'. Heredity undoubtedly predisposes to the condition, for several cases are frequently met with in one family. The enlargement is often noticed first after an attack of one of the exanthemata, especially measles, scarlet fever or diphtheria. Philp Mitchell found histological evidence of tuberculosis in 9 per cent of hypertrophied tonsils and in 38 per cent of the tonsils removed from patients suffering from tuberculous cervical glands. At Johns Hopkins Hospital, 366 cases of enlarged cervical glands were subjected to tonsillectomy, and in 309 of these the glandular swelling subsided. It is important to recognize the tonsils as a portal of systemic infection. Cases of rheumatic manifestations in childhood have been cured by removal of the tonsils, although the results of tonsillectomy in chorea, goitre and nephritis are less convincing. The remote effects of tonsillar sepsis have recently attracted attention. In myositis, fibrositis and chronic arthritis the tonsils rank next to the teeth as a focus of infection, and the etiological importance of throat affections in rheumatoid arthritis is under-estimated, but tonsillectomy cannot influence the course of the disease unless it is performed at an early stage. In such cases, where the arthritis follows or is associated with tonsillitis, or even in the absence of tonsillitis when pus may be expressed from the crypts, there need be no hesitation in recommending tonsillectomy. One must, however, discriminate between the thin fluid pus which indicates septic infection, and the white caseous masses which may often be expressed from the crypts of a 'normal' tonsil.

The symptoms depend to a great extent on the amount of the hyper-trophy, and also on the presence of adenoid vegetations, which are so

frequently found in children in association with enlarged tonsils. Where the hypertrophy is marked, or adenoid vegetations are present, the respiration is interfered with and the patient becomes a mouth-breather ; the result of this is discussed in the chapter dealing with diseases of the nasopharynx. The voice is also affected, so that the child speaks as if its mouth were full ; the cervical lymphatic glands are nearly always enlarged, sore throat is liable to occur, and an irritating cough is a frequent symptom. On inspection in typical and well-marked cases, the tonsils are found projecting into the mouth and appear almost like cherries ; the hypertrophy may be so extreme that the tonsils actually meet in the middle line. Sometimes, although there is definite hypertrophy, the tonsils are of the so-called 'buried' variety and do not protrude beyond the faucial pillars.

2. **Chronic Lacunar Tonsillitis** is commonly met with in adults and results from repeated attacks of acute lacunar tonsillitis. Cheesy matter collects in the crypts of the tonsils, and can frequently be expressed as white particles, which have a very offensive smell and taste. The whole tonsil may be riddled with such collections, and some of the cheesy matter may accumulate in the supratonsillar fossa. On rare occasions one of the crypts becomes distended owing to the blocking of its mouth and a smooth yellow swelling appears on the surface of the tonsil ; if this is opened, yellow creamy fluid and débris escape.

APPEARANCES.—On examining a typical case, one or more white particles may be seen lying in the mouths of the tonsillar crypts ; at first sight they resemble the excrescences seen in keratosis pharyngis, but they differ from this condition in that they can be easily wiped off ; the diagnosis should not, therefore, be difficult. The liability to repeated attacks of sore throat from which these patients suffer, the discomfort they experience from the unpleasant smell and taste accompanying the discharge of the particles and the ill effects which the continual ingestion of septic matter has on the digestion, all call for active treatment. It cannot be too strongly emphasized that the mere size of a tonsil is no guide to its septicity ; indeed, small tonsils are often the worst offenders. It is often difficult to decide, especially in adults, whether a given tonsil is 'septic' or not. Redness and congestion of the margins of the anterior pillar of the fauces is said to indicate a septic infection of the subjacent tonsil (Lott). A valuable test consists in pressing upon the anterior pillar with the end of a tongue depressor so as to squeeze out pus from the crypts. Again, the crypts may be aspirated by a small Bier's suction glass.

TREATMENT.—Treatment is necessary when : (*a*) The tonsils are sufficiently large to interfere with respiration or with speech ; (*b*) the cervical lymphatic glands are enlarged, especially if this is due to invasion by tubercle ; (*c*) there are recurring sore throats, or persistent reflex cough ; or in (*d*) systemic infections traceable to a focus in the tonsil ; (*e*) diphtheria carriers where the infection is persistent. Conservative treatment is of little value, as will readily be understood when we remember that the tonsil is riddled by crypts which extend as far as the lateral aspect (capsular surface), and naturally cannot be disinfected by

PLATE XIV

LARYNGOSCOPY, BRONCHOSCOPY, ŒSOPHAGOSCOPY

A

B

C

D

E

F

(A) Position of patient on operating table and method of holding the head. (Note shoulders held on table by the second assistant) ; (B) Direct laryngoscopy ; (C) Bronchoscopy, introduction of bronchoscope through the laryngoscope. (D) Bronchoscopy, examination of the lower right bronchi ; (E) Œsophagoscopy, introduction of the œsophagoscope. (Note the elevation of the patient's head) ; (F) Œsophagoscopy, examination of the lower end of the œsophagus. (Note the position of the patient—shoulders beyond the end of the operating-table.)

any surface application.   Painting with resorcin, 5 gr. in 1 oz. glycerin, may be of slight benefit, but cannot be regarded as curative.   The use of caustic potash in the form of 'London paste', as used by Morell Mackenzie, has been advised (Irwin Moore).   The paste is held against the surface of the tonsil by a special applicator.   When operation is contra-indicated the method may prove useful.   Dan McKenzie, in his book on "Diathermy in Otolaryngology," recommends surgical diathermy as the best means of securing gradual destruction of the tonsil, when the operation of tonsillectomy is contra-indicated on account of heart disease, exophthalmic goitre, nervousness, etc.   The tonsil having been anæsthetized by peritonsillar injection of 2 per cent novocain, a curved blunt electrode is passed into the tonsillar fossa and the current is turned on and slowly increased, until coagulation causes pallor of the tissues around the electrode.   A week later the opposite tonsillar fossa is treated, and by subsequent sittings at weekly intervals the remaining parts of the tonsil are gradually destroyed. The treatment may occupy several months, but the results are said to be very satis-factory.   The use of X rays and of radium are methods tried in America, with vari-able results.   The radical and obviously the most effective treatment is tonsillec-tomy.

THE OPERATION OF TONSILLECTOMY.

The indications have already been mentioned.   Various objections to the operation may be here discussed.   It may be alleged that, in a child, the enlargement may diminish as the child grows.   This is

Fig. 70.—Tonsil enucleated by guil-lotine. (1) Buried portion enclosed within capsule ; (2) Projecting lower pole.

true in some cases, but in the interval the health and growth of the patient will suffer from the obstruction to breathing, from the septic infection and from the renewed feverish attacks.   Should he contract scarlet fever or diphtheria the risk of a serious illness will be greater. In the adult, perhaps the most frequent objection to operation is that it will have a deleterious effect upon the voice.   To this the reply may be made that, although there may follow, in trained singers, some altera-tion or loss of tone which will only be recovered by a period of further training, the ultimate result will be good.   In all cases the speaking voice will be improved, and there should be no hesitation in recommending the operation to those whose singing voices are only in process of train-ing.   When dealing with the established singer, great caution must be exercised.   As regards the method of operating, there can be no question that the tonsil should in all cases be completely removed or 'enucleated' along with its capsule (*Fig.* 70).   Partial removal (tonsillotomy) is now obsolete.   Whatever the method employed, and whatever the anæsthetic, the patient must in all cases be prepared for operation by administering a purgative on the previous day and by withholding all food on the

morning of operation. If ether is to be used, a hypodermic injection of $\frac{1}{100}$ gr. of atropine should be given half an hour beforehand to check secretion of mucus. The possibility of hæmophilia in the family should be ascertained.

Two methods of tonsillectomy are in vogue : (1) *By means of the guillotine ;* (2) *By dissection.* Speaking generally, the guillotine method is advised for children, the dissection method for adults.

1. **The Guillotine Method.**—This operation, as now generally practised, was introduced by Whillis and Pybus, of Newcastle, in 1910, and is applicable to the great majority of cases in children. Ether given by the open method is the favourite anæsthetic in some quarters. In Edinburgh, ethyl chloride has for some years given perfect satisfaction. Anæsthesia is short (under two minutes), but is safe, and in expert hands there is ample time to remove both tonsils and also any coexisting adenoids. The drug is administered in an inhaler, and is allowed to evaporate slowly by placing the glass tube containing the dose (3 to 5 c.c.) in a cup of hot water. The vapour thus gradually evaporates and enters the bag, while deeper anæsthesia may be secured by filling the bag with oxygen before use. The patient lies on his back on the table, and the gag (Doyen's or Sydenham's) is inserted before the face-piece of the inhaler is applied. As soon as relaxation is secured, indicating a suitable degree of anæsthesia, the head of the table is lowered ; this prevents the entry of blood into the larynx. The same end may be secured, and with less obstruction to venous return, by placing a hard pillow beneath the shoulder-blades, and allowing the head to rest on the table in an extended position (*Fig.* 71).

Fig. 71.—Position of patient for tonsil operation.

The patient having been anæsthetized, the correct position secured, and the gag opened sufficiently (not too widely, as that tends to embarrass breathing), the guillotine is introduced like a tongue depressor, and the ring is applied so that the upper surface (i.e., the surface opposite the handle) lies towards the tonsil. Beginning at the lower pole, the ring of the guillotine is then passed over the tonsil (*Fig.* 72). Next, the distal end of the guillotine is pushed behind the tonsil, which is at the same time levered forwards by causing the shaft of the instrument to cross the opposite corner of the mouth and to take a horizontal direction. A swelling of the palate, corresponding to the upper pole of the tonsil, will now be observed. By pressing upon this swelling with the left thumb or forefinger the entire tonsil is caused to enter the guillotine (*Fig.* 73), and it is held there while the blade is pushed home with the right thumb or, in the case of a scissor-handled instrument, by a grasping movement. A firm and steady pull withdraws the instrument, with the tonsil lying on its lower surface (*Fig.* 74). Care must be taken that no part of the anterior pillar or of the uvula is included in

the grasp of the guillotine, an accident which may very easily happen, especially if too large an instrument is used. After driving home the blade, some operators twist the guillotine medially, thus first freeing the upper pole. The tip of the index finger of the free hand is then inserted behind the upper pole and, while pulling on the instrument, the tonsil is shelled out by a downward stripping action of the finger tip. This method prevents damage to the faucial pillars, especially the posterior. The exact pattern of guillotine is of little moment, and each operator has his favourite model.
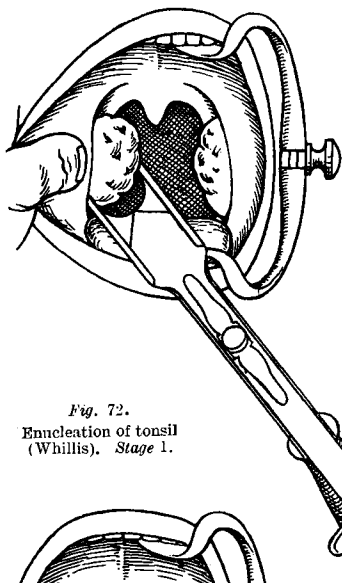
Fig. 72.
Enucleation of tonsil
(Whillis). Stage 1.
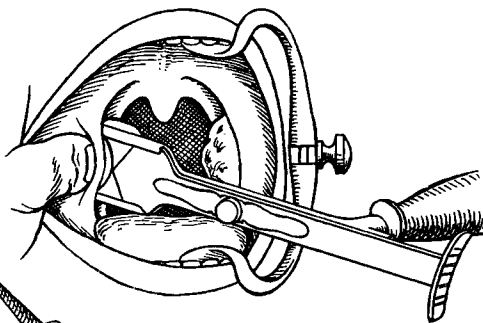
Fig. 73.—Enucleation of tonsil (Whillis).
Stage 2.

The guillotine illustrated in *Figs.* 72–74 is J. D. Lithgow's pattern. Heath's is simple and easily cleaned, while Ballenger's and O'Malley's are good examples of the scissor-handled variety. The shaft should be strong and inflexible, the ring of medium size ($\frac{3}{4}$ in. is the most useful), and the blade well blunted before use in order to diminish the amount of hæmorrhage. Immediately after one tonsil has been re-

Fig. 74.—Enucleation of tonsil
(Whillis). Stage 3.

moved, the second is enucleated in a similar manner and, finally, any adenoids are removed as described in a subsequent chapter. The patient is then turned face downwards until the effect of the anæsthetic is beginning to pass off, when he may be propped up and allowed to expectorate. Sponging the face and nape of the neck with ice-cold water will hasten recovery from the anæsthetic and will assist in checking hæmorrhage. *Before the patient returns to bed, the throat should be inspected, so as to ascertain that all bleeding has ceased.*

After-treatment will consist in placing the patient in bed in the

recumbent lateral position, with knees and hips flexed, and with a pillow behind him so as to prevent him from rolling over on to his back. He should remain in bed for two days, during which time the food should consist of soups, jellies, custards, etc. Ice cream is very acceptable and soothing. Milk is unsuitable at first, as it forms a disagreeable sticky compound with mucus in the mouth. An aperient may be administered on the following day. A mild antiseptic spray or mouth-wash, such as potassium permanganate in very weak solution, glycothymoline, or listerine, may be used for a week. The parents or friends of the patient should be warned that during the first week or ten days the tonsil cavities will be covered by a white slough which will disappear as healing proceeds.

As has already been stated, the vast majority of cases, in children, may be treated by the guillotine method, and in Edinburgh it is regarded as the routine operation. Mention may here be made of the Sluder method (1909), which consists in encircling the tonsil with the guillotine and then, before driving home the blade, pressing it against the eminentia alveolaris, the bony prominence on the mandible below the last molar tooth. It may also be mentioned that StClair Thomson (1901) described a method of completely removing the tonsil by dragging it with the aid of a vulsellum through the ring of the guillotine, a small-sized instrument being used.

2. The Dissection Method.—This is a major operation which may be reserved for special cases, but it is only fair to state that by certain operators, notably in London, it is employed in every case. Perhaps the usual practice is to employ it only for such cases as cannot be suitable for the guillotine method ; for example, tonsils which have been the seat of quinsy, as a result of which the capsule is adherent to surrounding parts and cannot be invaginated into the guillotine ; or septic remains of tonsils which have previously been removed in part ; or tonsils in adult patients who desire operation under local anæsthesia. Whatever method is adopted the patient should receive a hypodermic injection of atropine, $\frac{1}{100}$ gr., half an hour before the operation. The majority of operators, and indeed also the majority of patients, prefer operation under general anæsthesia (intratracheal ether), the patient lying on his back as illustrated in *Fig.* 71. Otherwise, the operative technique is the same as that employed when local anæsthesia is chosen, as will presently be described.

Local anæsthesia is preferred by some operators, as hæmostasis may at the same time be secured by the use of adrenalin. The solution consists of 0·5 or 1 per cent novocain, with 5 min. of adrenalin chloride (1–1000) to each fluid drachm, and using a curved needle ; the novocain solution is injected into the posterior pillar ; the anterior pillar is then injected. The tonsil is grasped with a vulsellum and gently pulled in a medial direction ; this enables its lateral (capsular) surface to be outlined through the anterior pillar and, using a straight needle ; a syringeful of solution is injected lateral to the tonsil, i.e., into the peritonsillar tissue. Further injections may be made into the plica triangularis to ensure anæsthesia of the lower pole. The aim of the injection is to surround the tonsil with the solution and at least an ounce should be employed. Anæsthesia is immediate, but it is advisable to wait five or ten minutes

PLATE X

ENUCLEATION OF TONSIL BY DISSECTION
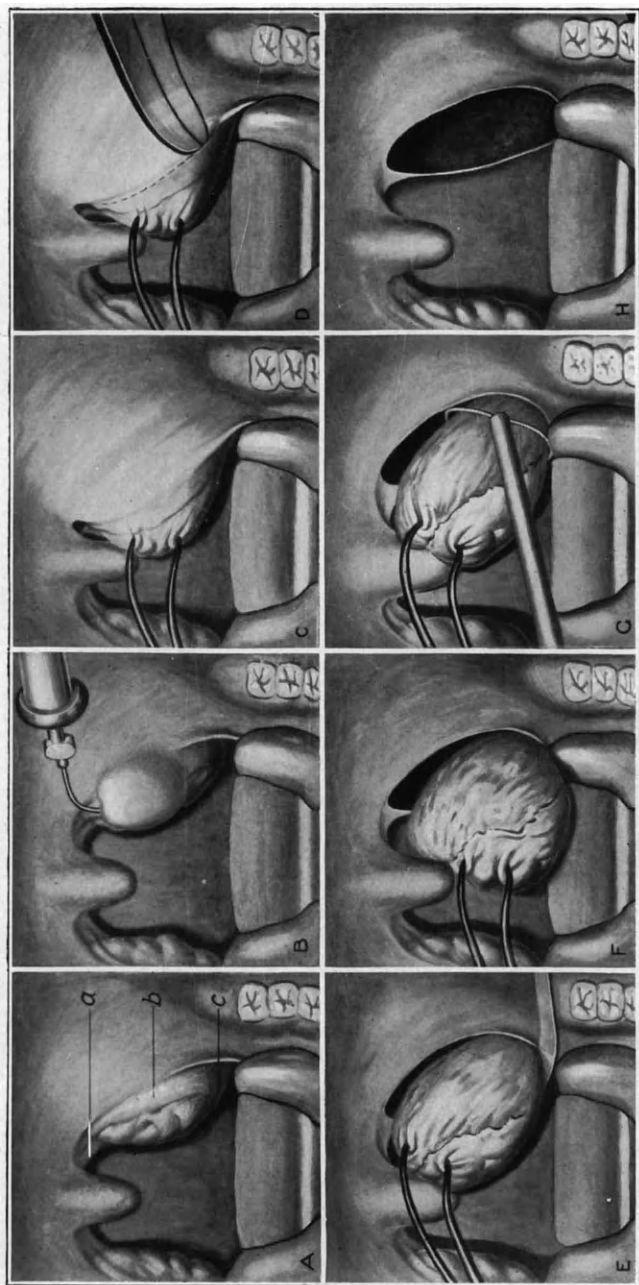
(A) Shows the points (*a*, *b*, *c*) at which the local anæsthetic is injected. (B) Shows infiltration of the injected anæsthetic. (C) Tonsil grasped and pulled medially. (D) Commencement of dissection with scissors. (E) Upper pole of tonsil freed. (F) Dissection completed. (G) Snare in position. (H) Tonsillar fossa after removal of tonsil.

in order to allow the local œdema to subside. The patient is seated in a chair in front of a good light (daylight is usually sufficient), and the operator, seated in front of him, seizes the tonsil with a vulsellum, and with scissors divides the mucosa close to the anterior pillar, so as to expose the white, shining capsule (*Plate X*, D). By dissecting with a tissue separator or pair of scissors the tonsil is gradually separated from the faucial pillars ; a snare (Eve's) is then passed over the vulsellum and tightened well down over the base of the tonsil so as to divide its final attachments (*Plate X*, G). After the first tonsil has been removed, a small gauze and wool ball may be held in the fossa by a suitable holder and any oozing is thus controlled. In this way hæmorrhage is reduced to a minimum. and will in most cases be checked entirely by gargling with a tumblerful of cold water containing a tablespoonful of hydrogen peroxide.

Pain following operation may be relieved by morphine or one of its substitutes, and by the local application of powdered aspirin to the tonsil cavities. A 'throat bath' of 10 gr. of aspirin in half a tumblerful of warm water is very soothing to the adult patient (Scott Stevenson). Painting the raw cavities with carbolized resin (dental) at the close of the operation will assist in arresting hæmorrhage and in relieving pain.

The operation of tonsillectomy by the dissection method, u n d e r g e n e r a l anæsthesia, was introduced by Waugh, of London, in 1909. Some surgeons have adopted it as a routine procedure for all cases, but the majority employ the guillotine method for children, reserving the dissection method for adults. The dissection method is certainly a more accurate and exact operation, the pala-tine arches are preserved intact, and

Fig. 75.—The use of Waugh's gag in conjunction with a cheek retractor and tongue clip.

hæmorrhage is controlled by securing with forceps each bleeding point as the tonsil is separated from its bed. The tonsil is first grasped by a vulsellum (Tilley's), the capsule over the upper pole of the tonsil is exposed by means of a long pair of mouse-toothed dissecting forceps, and by using the same forceps, aided by gauze dissection, the entire tonsil is removed. A snare is sometimes used to complete the separation of the lower pole— the line of cleavage being not so apparent in this region. The Boyle-Davis gag, which combines gag and tongue depressor, is of great assistance, but an excellent exposure of the area of operation may be secured by using Waugh's gag in conjunction with a cheek retractor and tongue clip as shown in *Fig.* 75. Intratracheal ether anæsthesia is used, administered by Shipway's or other apparatus, and a suction apparatus such as that of Moseley may assist in clearing blood from the field of operation. It is only fair to state that the dissection method demands considerably more surgical skill than does the guillotine method.

Hæmorrhage following Tonsillectomy.—This alarming complication is fortunately rare. The hæmorrhage is nearly always primary, and it is therefore important to see that all bleeding has ceased before the patient leaves the operating table. If the swab or sponge be moistened in hydrogen peroxide, its hæmostatic value will be enhanced. The clamp devised by E. Watson-Williams is useful as a temporary measure. One blade, suitably padded, is applied to the bleeding area; the other blade provides counter-pressure behind the angle of the jaw. Should these simple methods fail to arrest the hæmorrhage, search must be made, under good illumination, for the bleeding vessel, which should then be clamped with long artery forceps and ligatured (*Fig.* 76). A small vertical vein at the upper part of the tonsil bed, behind the anterior pillar, is often the source of troublesome hæmorrhage. Certain authorities have advised the suturing together of the anterior and posterior pillars and have invented instruments to facilitate this. The method should be reserved for exceptional cases in which the bleeding vessel cannot be found and ligatured. If the surgeon is summoned to attend a case of hæmorrhage several hours after tonsillectomy, he will generally find, on inspection, that the tonsillar fossa on one side is occupied by an adherent tarry clot beneath which fresh blood is constantly oozing. The first step in treatment consists in the removal of the clot. Thereafter the bleeding is arrested as if it were occurring during the operation. In many cases it is sufficient to apply pressure by means of a sponge or swab in a sponge-holder. This is held firmly in the bleeding fossa, the axis of the holder being directed from the opposite angle of the mouth.

Fig. 76.—Method of ligaturing bleeding vessel following tonsil operation. (*Coakley.*)

CALCULUS OF THE TONSIL (TONSILLOLITH).

This may originate in the tonsillar crypts as a result of chronic inflammation ; one or more may be formed and they may reach a very large size, as is shown by a case in which the calculus was over an inch in diameter. They may be detected with a probe or by palpation, or, occasionally, a portion may be seen projecting from the tonsil. Inflammation is liable to occur round the calculus which is then extruded. When diagnosed, the concretion should be removed either by itself, or, if the tonsil be enlarged or septic, complete enucleation may be performed.

BONE AND CARTILAGE IN THE TONSIL REGION.

Small islands of cartilage or, more rarely, of bone have been demonstrated in about one-third of all tonsils submitted to microscopic examination. The bone and cartilage are of embryonic origin and represent

the remains of the first and second branchial arches.   The osseous or cartilaginous tumours which occasionally occur within the tonsil doubtless originate from these islets.

Another source of bone within the tonsil is the *styloid process* of the temporal bone, which may be of such a length as to project into the tonsillar fossa.   As a rule it causes no symptoms, but it may be discovered during the operation of tonsillectomy.   Cases are on record, however, in which the elongated styloid process gave rise to pain and difficulty of swallowing.   Such cases illustrate the importance of palpation of the tonsil region with the finger as an aid to diagnosis.   On palpation, the bony projection is easily felt and its removal will be followed by cure.

CHAPTER XX.

OTHER AFFECTIONS OF THE PHARYNX, INCLUDING TUMOURS AND NEUROSES.

KERATOSIS OF THE PHARYNX.

THIS is not a very common affection. It was formerly supposed to be the result of the accumulation of leptothrix in the pharynx; but Siebenmann and Brown Kelly have shown that it is due to a horny outgrowth from the crypts of the tonsils, composed of keratinized epithelial cells which are arranged in concentric layers within the crypts. The leptothrix is merely an accidental contamination and not the cause of the disease. On examination, white chalk-like excrescences are seen projecting from the crypts of the tonsils; there is an entire absence of congestion around them, and they cannot be wiped off (*Plate IX*, 1, p. 128). The projections may be found wherever there is lymphoid tissue within the area known as Waldeyer's ring—the region bounded above by the pharyngeal tonsil, below by the lingual tonsil and laterally by the faucial tonsils. Cases of keratosis laryngis have been reported (Logan Turner and Porter).

SYMPTOMS.—There may be slight irritation of the throat; but as a rule there are no symptoms, and advice is not infrequently sought by patients who have discovered accidentally the white spots in their throats. If a careful examination is made, there should not be much difficulty in arriving at a correct diagnosis. The absence of constitutional disturbance and of local inflammation, the horny nature of the outgrowths, and the presence of similar excrescences upon the lingual tonsil, revealed by using the laryngoscopic mirror, should prevent the condition from being mistaken for lacunar tonsillitis, the only other affection with which it is likely to be confounded. In doubtful cases the microscope may be called into requisition.

TREATMENT has generally but little effect and it is as well to refrain from interference, as the condition is quite harmless and often disappears spontaneously, especially if the general health improves.

HÆMORRHAGE FROM THE PHARYNX.

This is an unusual condition, although patients frequently seek advice for 'bleeding from the throat'. In the vast majority of these cases the blood really comes from the lungs, the cause of the hæmoptysis being pulmonary tuberculosis; in other cases the hæmorrhage may proceed from the larynx, the nasopharynx, the nose, the trachea, or the œsophagus, and is due to such conditions as laryngeal phthisis, adenoid

vegetations, or epistaxis. When the pharynx is the site of the bleeding, it may be the result of the ulceration of syphilis, tubercle, or malignant disease ; but when there is no gross morbid lesion to account for it, the probable cause is either some blood disease, such as hæmophilia, pernicious anæmia, or leukæmia, or else the rupture of enlarged veins in the pharynx in gout. Another possible cause is malignant disease of the trachea and bronchi, which may now be diagnosed by the bronchoscope.

Malingerers, however, occasionally produce artificial bleeding from the pharynx in the attempt to simulate pulmonary phthisis. Bleeding from the mouth due to spongy gums may also be mistaken for hæmorrhage from the pharynx.

It is obvious, from this rather formidable list of possible errors, that a very careful examination of the upper air-passages must be made when a patient complains of this symptom, and a diagnosis of pharyngeal hæmorrhage must not be arrived at unless the bleeding-point is actually seen. It is especially important in every case to *exclude pulmonary tuberculosis.* Cases are on record in which a bleeding-point in the trachea or bronchi was discovered by the use of the bronchoscope. When the pharynx is the site of the hæmorrhage, the patient should be given ice to suck, and the bleeding-point may be touched with the galvanocautery, or with a bead of chromic acid fused on a probe. Any general condition underlying the hæmorrhage should also be treated.

FOREIGN BODIES IN THE PHARYNX.

A great variety of foreign bodies has gained access to the food-passages ; of these, fish and other small bones are specially liable to be arrested by the pillars of the fauces, in the crypts of the tonsils, at the base of the tongue, or in the posterior wall of the pharynx. The power of localization in the air-passages is very poor, and patients not infrequently refer their sensations to a point at some distance from the site in which the foreign body has been caught. Another common fallacy is due to the fact that the feeling of pain or pricking continues unabated for a considerable time after the object has passed on, and has been either swallowed or coughed up. So vivid are these impressions that it is often extremely difficult to persuade such patients that the foreign body is not lodged in the place they indicate.

SYMPTOMS.—These are pain or a sensation of pricking and sometimes cough. If the foreign body passes beyond the pharynx, the symptoms may become urgent ; this will be discussed later (Chapter XXXI).

DIAGNOSIS.—It is of great importance to begin the examination by inspection with good illumination. The search must be thorough and systematic, as in some cases the foreign body, e.g., a transparent fish-bone, is liable to escape notice. Palpation should not be resorted to at first, for fear of dislodging the foreign body or embedding it deeper in the tissues ; if it is not detected, a complete examination of the food- and air-passages may have to be made ; but if it is seen in the pharynx, it can as a rule be removed easily with forceps.

TUMOURS OF THE PHARYNX.

Non-malignant Tumours.—Of the simple tumours met with in the throat, papillomata are the most frequent. They may be found attached to the uvula, the margins of the soft palate, or the pillars of the fauces ; they are light pink in colour, have a cauliflower or granular surface, and may be sessile or pedunculated. Adenomata, fibromata, angiomata, cysts, dermoid cysts and osteomata have also been observed ; but they occur so rarely that it is unnecessary to enter into descriptions of them. Mixed parotid tumours are occasionally met with.

SYMPTOMS.—Those produced by simple tumours are generally due to their mechanical interference, and diagnosis is made by inspection.

TREATMENT.—Papillomata can usually be removed with scissors, or, if sessile, they may be destroyed with the cautery point. In the absence of symptoms, the removal of such growths need not be undertaken ; but where treatment is necessary, it must be carried out on general surgical principles.

Malignant Tumours.—Malignant disease is nearly always primary in the pharynx ; both carcinomata and sarcomata are met with ; carcinoma is rarely found before the age of forty, but sarcoma is met with at any age. Carcinoma may attack the soft palate, the pillars of the fauces, or the tonsils ; it presents at first a hard, uneven surface surrounded by an area of induration which tends to ulcerate early ; the ulceration extends both laterally and in depth and the floor of the ulcer is covered by mucopus ; the glands in the neck soon become involved and form hard immobile masses.

Lymphosarcoma is the variety of sarcoma most frequently met with in the pharynx, though round-celled, mixed round- and spindle-celled, and melanotic sarcomata occur. Sarcoma tends to grow rather rapidly, and when it has attained a considerable size the mucous membrane covering it appears bright-red and succulent. The growth usually begins in the tonsil ; it is not so hard as carcinoma ; it remains for a time limited by the capsule of the tonsil, then passes this barrier and spreads by invasion of deeper structures, and very frequently involves the region behind the angle of the jaw, and causes large swellings in the neck. Lymphosarcoma tends to ulcerate early and to spread superficially.

SYMPTOMS.—Pain is a prominent symptom in most cases of carcinoma ; it is usually lancinating in character and radiates towards the ears ; there is frequently considerable salivation and at a later stage the tongue may become much restricted in its movements ; difficulty may then be experienced in opening the mouth. A foul-smelling discharge follows the breaking down of the tumour, and the patient loses weight rapidly. In sarcoma, pain is not so common, the symptoms being due more to the mechanical interference from the size of the growth. Speech becomes thick and throaty and swallowing may be difficult.

DIAGNOSIS.—This may present considerable difficulty. Carcinoma has to be distinguished from primary chancre, breaking-down gumma, ulceration due to some septic process such as is caused by the pneumo-coccus, and even from acute tonsillitis ; while sarcoma has to be diagnosed

from tumours of a simple nature. Most cases of sarcoma of the tonsil have, in their early stages, been mistaken for quinsy and have been incised, but only a little blood has escaped. A chronic painless swelling resembling quinsy should be viewed with suspicion. The syphilitic ulcer is more rapidly destructive than the malignant, but the patient does not lose weight so rapidly, and pain is less. In its early stages a gumma may be mistaken for a malignant growth. In doubtful cases it is advisable to remove portions of the tumour for microscopical examination, though the pathologist is not always prepared to give a definite opinion on the nature of such fragments. When the diagnosis lies between carcinoma and tertiary syphilis it is well to remember the hard raised edge of the malignant ulcer in contrast with the congested serpiginous edge of the syphilitic ulcer. Often the diagnosis is difficult, and cancer may appear to improve under antisyphilitic treatment. A primary chancre will hardly cause serious difficulty in the diagnosis, as it is unlikely to occur at the age when carcinoma is met with ; moreover, the appearance of secondary manifestations will clear up the diagnosis. Ulcerating sarcoma may be mistaken for tuberculous ulceration ; but the nocturnal rises of temperature, the existence of a pulmonary lesion, and the presence of tubercle bacilli in the sputum should distinguish the latter conditon. The possible existence of Hodgkin's disease should also be borne in mind.

PROGNOSIS.—The prognosis in all varieties of malignant disease is very grave, especially in the case of carcinoma, for the pharynx is a region from which it is especially difficult to eradicate disease. The presence of glandular metastases greatly increases the gravity of the prognosis. Sarcoma of the tonsil, however, remains for a time confined within the capsule, and prompt enucleation of the tonsil will frequently cure such cases.

TREATMENT.—This should be operative if possible ; unfortunately these cases do not offer much hope of a successful issue ; the decision as to the practicability of removal must rest with the surgeon. In early cases it may be possible to remove the growth through the mouth ; sarcoma limited to the tonsil may, for example, be treated by tonsillectomy. When the disease is more widespread it may be approached by lateral pharyngotomy (Trotter), the cervical lymphatic glands being removed at the same time.

Diathermy has recently given encouraging results in the treatment of malignant growths. It consists in the destruction of tissue by the intense heat of a high-frequency current. If care is taken to proceed slowly, bleeding may be avoided. The method has great advantages, e.g., absence of shock, little or no pain after operation, little cicatrization in healing (Harmer). Inoperable cases may often be relieved of pain and dysphagia by diathermy, but the method is deserving of application in operable cases also, when it is superior to ordinary surgical methods. Probably the best treatment at the present time is a combination of diathermy and radium (Norman Patterson).

As regards the use of radium, this agent is of value in operable as well as in inoperable cases, and in the former case it may with advantage

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be combined with surgical methods. For sarcomata radium must be regarded as a method of temporary cure, causing rapid and apparently complete disappearance of the growth in many cases. The radium acts with greater certainty when inserted into the tumour, and its dosage is measured in milligram-hours.

NEUROSES.

1.—Sensory Neuroses.

Anæsthesia is most commonly met with after diphtheria ; it may also be found in diseases of the central nervous system, such as syringo-myelia, bulbar paralysis and intracranial tumours. In most cases it is associated with paræsthesia and paralysis of the soft palate. Diminished sensibility of the pharynx may occur in hysteria.

Hyperæsthesia, Neuralgia, and Paræsthesia.—

Hyperæsthesia of the pharynx is a very common condition, especially in rheumatic and gouty individuals and in those who over-indulge in alcohol and tobacco ; but in these cases it is usually associated with pharyngitis.

Neuralgia of the pharynx is not a common affection. It may be associated with pain in the tongue, the side of the neck, the cheek and the nose. This form of neuralgia is termed by Sluder 'sphenopalatine ganglion neurosis'. Treatment consists in the application of cocaine to, or injection of alcohol into, the sphenopalatine ganglion (Meckel), which is situated close to the lateral nasal wall and to the posterior end of the middle concha (p. 8 and *Plate VI*, A, p. 90).

Paræsthesia.—By this is understood some abnormal sensation in the throat, e.g., a feeling as if there were a foreign body or a lump in it, while sometimes there is an irritation causing a frequent desire to clear the throat. On examination, very little can be made out as a rule ; but it must be remembered that similar symptoms may be produced by enlargement of the lingual tonsil, while in other cases a few granules may be seen on the posterior wall of the pharynx ; before arriving at a diagnosis of a functional neurosis, care must therefore be taken to exclude all possibility of organic disease ; it may be a very early symptom of a malignant growth or of pulmonary tuberculosis. A very obstinate form of paræsthesia is sometimes met with in women about the time of the menopause, and is liable to persist in spite of treatment until this phase is well over.

TREATMENT.—It is most important in the treatment of these cases to attend to the general health. In anæmia and chlorosis, iron and arsenic may be prescribed ; in anæsthesia due to diphtheria, faradization or galvanism to the throat, and hypodermic injections of strychnine, are indicated. Massage of the neck and cold douching may be tried ; but the local application of pigments should be avoided in cases of paræsthesia, as they do but little good, and patients are liable to become more depressed by their symptoms when treatment fails to produce improvement.

In paræsthesia due to the menopause, Semon has found that spontaneous cure is likely to take place. As a neurosis of secretion,

Schech has described cases in which there has been a constant desire to expectorate. McBride has found in such individuals, when the mucosa of the pharynx was healthy and there was no abnormal secretion in the nose or larynx, that the sputum was usually frothy and mingled with a little viscid mucus, and was produced by the action of clearing the throat. The patient should be assured that there is no disease, and should be advised to refrain from 'hawking' and spitting.

2.—MOTOR NEUROSES.

Rhythmic Movements of the Soft Palate (Nystagmus of the Pharynx).— This is a somewhat rare condition. The movements may be limited to the soft palate, or they may also involve the floor of the mouth, the larynx and even the diaphragm. They may be accompanied by a clicking sound, but often the patient is unaware of the contractions. In some cases they are due to trigeminal neuralgia ; in others they have been attributed to functional disturbance of the central nervous system, and they may also be due to organic disease of the brain.

TREATMENT must be conducted on general principles.

Paralysis of the Soft Palate.—The most common cause of this affection is diphtheria ; it may also be due to diseases of the central nervous system implicating the spinal accessory, more especially to bulbar paralysis, but also to syringomyelia, embolism, tumours, or basal meningitis. Influenza has been recorded as a cause, as also have lead and arsenic poisoning. The paralysis is generally unilateral, but may be bilateral ; when unilateral, the velum is drawn to the healthy side, but when bilateral it hangs loosely and does not respond to stimuli ; the voice is nasal (rhinolalia aperta), and fluid escapes into the nose when drinking. Occasionally, temporary paralysis is observed after operation for the removal of tonsils.

TREATMENT.—In diphtheritic or toxic paralysis, hypodermic injections of strychnine and local faradization should be employed. In syphilitic gumma or pachymeningitis, the appropriate treatment is indicated, while in central nervous lesions and in tumours no treatment is likely to prove successful.

CHAPTER XXI.

DISEASES OF THE NASOPHARYNX.

ACUTE INFLAMMATION.

ACUTE inflammation, beginning either in the nose or in the pharynx, may extend to the nasopharynx, and it is accordingly not uncommon to find its mucosa participating in an acute pharyngitis or rhinitis. Besides this we may recognize an acute inflammation which may be confined to the lymphoid tissue of the nasopharynx, and which resembles acute lacunar or follicular tonsillitis ; in such a case the pharyngeal tonsil is covered with mucopus (adenoiditis). This is a common cause of obscure feverish attacks in childhood. The inflammation is associated with pain and discomfort at the back of the nose, nasal obstruction, pain on swallowing and a rise in temperature. Examination of the pharynx is negative, but on posterior rhinoscopy the appearances described above are made out.

TREATMENT.—In so far as it is applicable, this is the same as for acute rhinitis. Cleansing the nose with a warm alkaline spray will give relief and hasten recovery.

CHRONIC POST-NASAL CATARRH.

ETIOLOGY.—Chronic inflammation, like the acute variety, may extend from the nose and fauces to the nasopharynx ; the causes of chronic rhinitis and of chronic pharyngitis may therefore produce chronic post-nasal catarrh. The affection is also favoured by nasal obstruction, even in the absence of rhinitis. It may be a manifestation of paranasal sinus suppuration.

APPEARANCES.—There may be merely a congestion of the mucosa which can also be observed in the pharynx and nose, or the mucous membrane may be rugose ; this irregularity is often chiefly marked in the vault, owing to the persistence to some extent of the pharyngeal tonsil. Chronic abscess of the remains of the median recess in the pharyngeal tonsil has been described (Tornwaldt). Mucus or mucopus may be seen adhering to the walls of the nasopharynx.

SYMPTOMS.—The chief symptom is the feeling of some accumulation at the back of the nose, causing a constant desire to clear the throat by drawing back through the nose ; this is followed by the expectoration of viscid secretion. The subjective disturbances vary greatly in different individuals, and are apparently quite independent of the extent of the objective changes.

TREATMENT.—If the symptoms appear to depend on the persistence and infection of the pharyngeal tonsil, or on paranasal sinus suppuration,

these should receive appropriate treatment. The general health of the patient must be considered, and the urine examined for sugar and albumin. When there is some definite nasal obstruction, any operative procedure is justifiable which will establish nasal respiration, and should be carried out. In the absence of such definite indications for interference, milder methods of treatment must be employed. In many cases an ammonium chloride inhaler will be found of service to diminish hypersecretion ; in other cases, however, no benefit results from this method of treatment. If there is much mucopurulent secretion, the nasal douche may be ordered, for it must be remembered that the nasopharynx as well as the nose is flushed out by this procedure. Astringent solutions, such as nitrate of silver or chloride of zinc, may be applied on a post-nasal applicator, or Mandl's pigment may be used (*see* Appendix). In gouty or plethoric individuals a course of Carlsbad salts may be prescribed ; and in neurasthenic patients general treatment is necessary. Excessive smoking and over-use of alcohol should be discountenanced in this as in other affections of the upper air-passages.

ADENOID VEGETATIONS, OR HYPERTROPHY OF THE PHARYNGEAL TONSIL.

This very common affection of childhood was first recognized in 1868 by Wilhelm Meyer, of Copenhagen.

ETIOLOGY.—Adenoid vegetations are met with in early life. The most common period for their occurrence is between the ages of four and fifteen, but they may also be found in infants, and in some cases are undoubtedly congenital. Adenoid hypertrophy is also met with in adults. Heredity may play some part in the etiology of the condition, for it is a common experience to find that several or all of the children of one family are affected. Climate is also a factor of some importance : a cold, damp atmosphere predisposes to the disease, while in a hot, dry climate, such as the south of Italy, it is met with more rarely.

PATHOLOGY.—Adenoid vegetations are an hypertrophy of the lymphoid tissue normally found in the vault of the nasopharynx in the child. The mass is composed of vertical folds separated by deep fissures and is of varying thickness and consistence (*Fig.* 77). In structure 'adenoids' resemble the faucial tonsils, except that there are no crypts and the surface is covered by ciliated epithelium ; the tissue is also more vascular and has relatively less connective tissue.

Fig. 77.—Mass of adenoids after removal from a child, age 3.

SYMPTOMS.—The symptoms vary according to the degree of hypertrophy. In marked cases the classical clinical picture is met with, which is the result of long-standing mouth-breathing and has for many years

been associated with this affection, the so-called adenoid facies (*Fig.* 78). Various clinical types may, however, be distinguished, depending on the most prominent group of symptoms.

Ear Symptoms.—In this group the chief symptoms are due to the aural complications, and the patients are brought complaining of deafness, which is the result of auditory-tube (Eustachian) obstruction or of a discharge from the ear. The great majority of cases of deafness in children are the result of adenoids. The deafness sometimes varies according to the weather, and is always worse when the child is suffering from a cold. The tympanic membranes are retracted, a valuable diagnostic sign of adenoids in children. Less frequently, the tympanic membrane is perforated and the meatus filled with sticky mucopus, a variety of chronic otitis media which is often curable by removal of adenoids, which constitute the source of infection.

Fig. 78.—Adenoid facies.

Nasal Symptoms.—The predominant symptoms may be snoring at night, mouth-breathing during the day, tendency to choking while eating, recurrent attacks of 'cold in the head', and constant nasal discharge. Speech is also affected, and as a result of the nasal obstruction is dull and lacking in resonance. Epistaxis is not uncommon.

Reflex and General Symptoms.—Many children who suffer from adenoids are dull and listless, easily tired and unable to concentrate. These mental symptoms have been grouped under the name 'aprosexia' (Guye). Night terrors are common in such patients. The teeth are often carious and crowded, and the arch of the palate is high. Physical development is frequently poor, and especially common are deformities of the chest which becomes flat and retracted. Enuresis nocturna and asthma are sometimes associated with adenoids, but the relationship may be accidental, and prognosis as to cure following operation must in such cases be guarded.
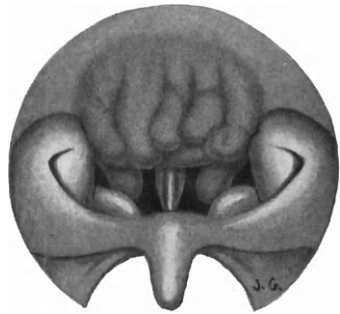
Fig. 79.—Adenoids as seen by posterior rhinoscopy.

APPEARANCES.—On posterior rhinoscopy, a lobulated mass, of the same colour as the mucous membrane, is seen in the nasopharynx (*Fig.* 79). It may be so slight as to form only a moderate projection

from the roof and not to encroach on the posterior nasal opening ; or it may hang down and hide a part or the whole of the septum and choanæ. Not infrequently some secretion is seen lying on the surface of the vegetations. The growths occasionally extend to the lateral walls and are in close relation to the mouths of the auditory tubes. It is in such cases especially that aural complications occur. In very rare instances the vegetations extend into the pharynx and project below the soft palate. Adenoid vegetations are frequently associated with enlargement of the faucial tonsils. The examination with the mirror can frequently be carried out successfully in quite young children. It is seldom necessary, or indeed desirable, to palpate the nasopharynx.

DIAGNOSIS.—The diagnosis is as a rule quite easy, but in the case of young infants it may not be possible to come to a definite conclusion prior to operation. In such cases, if syphilis can be excluded, it is wiser to give an anæsthetic and to introduce a small curette into the naso-pharynx. If adenoid vegetations are present, they will be removed ; but if the nasopharynx is free, no harm is done. The method of digital exploration should not be used where it is possible to make the diagnosis with the mirror, as the procedure is extremely disagreeable to the patient. Some observers, however, prefer this method, as they believe they can thereby make a truer estimate of the amount of adenoid vegetations present than is possible by posterior rhinoscopy. In all cases anterior rhinoscopy should be practised to ascertain the presence of other forms of obstruction, such as deflected nasal septum, enlarged conchæ, etc. The possibility of a coexistent infection of the paranasal sinuses must not be forgotten. Mild infections of the sinuses usually clear up after removal of adenoids in children, but direct treatment may be necessary, should the symptoms persist.

TREATMENT.—If adenoid vegetations are not well marked, and the symptoms are very slight or entirely absent, an operation should not be performed. Simple breathing exercises may be helpful in such cases and games in the open air should be encouraged. The patient should be seen again after an interval of a few months, when the progress of the case will determine if operative interference is necessary. When, how-ever, one or more of the cardinal symptoms are present, no time should be lost in removing the growths. It is not a sufficient reason against operation that the vegetations tend to atrophy at puberty, because the mischief is done in the meantime and is irreparable.

METHOD.—It is only humane to give a general anæsthetic when per-forming this operation, although in infants a single sweep of the curette is sufficient, and this may be carried out without anæsthesia. Ethyl chloride is an anæsthetic admirably suited to the purpose ; in skilful hands, and with an expert operator, one dose gives ample time to enucleate both tonsils with the guillotine and to remove completely the adenoid vegetations. As already mentioned in the section on TONSILLECTOMY (p. 136), it is a safe anæsthetic, and is so rapidly eliminated that the patient may sit up immediately after the operation and thus assist the arrest of hæmorrhage. Three c.c. is usually a sufficient dose for all ages ; in the case of adults, however, it is advisable to give 5 c.c. along with an

equal quantity of ether. The drug is administered in some form of inhaler such as Clover's ; it is pleasanter for the patient, and anæsthesia is more lasting, if given slowly by evaporation. During the induction of anæsthesia the patient lies on his back ; as soon as relaxation is secured, the head of the table is lowered, or the patient's shoulders are elevated on a pillow, as shown in *Fig.* 71 ; this prevents blood from entering the larynx during the operation. The gag (Doyen's or Waugh's) is then inserted, and to obviate any difficulty in the process, a mouth-prop may be placed between the teeth before the commencement of anæsthesia. The anæsthetist should keep the patient's head in the middle line and see that the gag does not slip. He stands on the left side of the patient, while the operator stands on the right side.
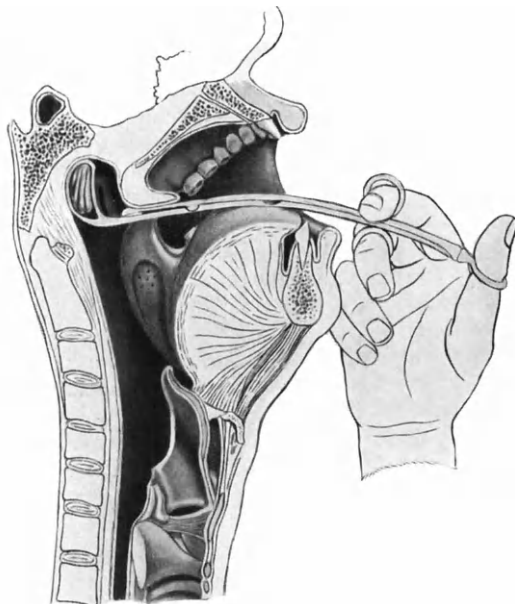
Fig. 80.—Removal of adenoids by the La Force adenotome (the ' box' of the instrument is represented as cut away to show the adenoid mass within it).

If the tonsils as well as the adenoids are to be removed, the former should be dealt with first, because it is necessary to see exactly where to place the guillotine.

For the removal of adenoids, some form of guarded curette is first employed (StClair Thomson's is an excellent pattern) ; it is introduced behind the soft palate, being held sideways till it has passed between the uvula and the lateral wall of the pharynx, when it is pressed against the roof of the nasopharynx, and is carried forward as far as possible in the middle line until it is stopped by the posterior free margin of the septum. With a sweeping motion, the roof and the posterior wall are scraped once by the curette, which is thereupon withdrawn. Another

curette is then taken (at this stage an unguarded one will do), and the nasopharynx is again scraped as before, first in the middle line and then slightly to either side. The La Force adenotome is regarded by some operators as a more efficient and accurate instrument than the curette (*Fig.* 80). If Hartmann's lateral ring-knife be used to scrape the fossæ of Rosenmüller, it is introduced in the same manner as the curette, but is made to scrape laterally, care being taken to keep behind the cushions of the auditory tubes. Finally, the operator may insert his index finger into the nasopharynx to make sure that all the adenoid vegetations have been removed. The gag is then withdrawn, and at the same time the patient is rapidly turned over on his face for a few seconds, after which he may be lifted into a sitting position which has the effect of stopping the hæmorrhage. As the dependent position of the head produces considerable bleeding, it is necessary in many cases to use sponges on sponge-holders to swab the pharynx during the operation, or the patient may be turned face downwards for two or three seconds, to allow the blood to escape.

The child should be kept in bed for two days after the operation, during which time only boiled food should be given, and for a week the diet should be limited to slops and food that is easily swallowed.

If reactionary hæmorrhage occurs some hours after the operation, it can almost always be stopped by sitting the patient bolt upright ; if, however, this procedure does not have the desired effect, pressure must be applied, after removal of the clots, by a swab or sponge dipped in a solution of peroxide of hydrogen (10 vol.) and held in the nasopharynx in a sponge-holder. Sometimes bleeding is kept up by the presence of a 'tag' of adenoid tissue which hangs down behind the palate. It may be easily removed with punch forceps. Post-operative treatment is similar to that already recommended for tonsillectomy. Breathing exercises are essential at this stage in order to correct the habit of mouth-breathing. Dental treatment may also be necessary.

FIBROMUCOUS POLYPUS OF THE NASOPHARYNX, OR ANTRO-CHOANAL POLYPUS.

This is described in detail under DISEASES OF THE NOSE AND PARA· NASAL SINUSES (p. 99).

NASOPHARYNGEAL FIBROMA.

This is a somewhat rare but very serious disease. It nearly always occurs in males between ten and twenty-five years of age. The tumour arises from the roof or posterior wall of the nasopharynx ; it is usually sessile and is attached to the periosteum. The growth is pink or red in colour and of a very firm consistence. Microscopically it consists of fibrous tissue with but few cells, and is rather richly supplied with blood-vessels, some of which may be greatly dilated. Some of these tumours are sarcomata and grow rapidly and extend at the expense of the tissue with which they come in contact, causing absorption and erosion of bone.

Ulceration may result, or synechiæ may form between the tumour and the neighbouring parts. Though the growth is thus locally malignant, metastases never form.

SYMPTOMS.—In the earlier stages nasal obstruction is the most prominent symptom ; this is accompanied by changes in the voice, such as are found in cases of adenoid vegetations, and which Wilhelm Meyer described by the name of 'dead speech'. In addition to the nasal obstruction, attacks of epistaxis occur from time to time. At a later stage, ulceration may take place accompanied by a fœtid nasal discharge. As the growth progresses, external deformities are produced, the nature of which depends on the direction in which the processes of the tumour force their way. If they extend into the nasal cavities, broadening of the nose and so-called 'frog-face' result. If the orbit is invaded, protrusion of the eyeball follows and, when the growth extends downwards, deglutition and even respiration may become impaired. During the later stages, severe pain is common, due to pressure on the nerves, and deafness follows as a result of implication of the auditory tubes. Finally, the growths may extend towards the brain ; this is followed by the development of cerebral symptoms and meningitis. Death may result from exhaustion, hæmorrhage, sepsis, or from an intracranial complication.

APPEARANCES.—On examination of the pharynx, bulging of the soft palate may be observed, due to the pressure of the tumour. In other cases the lower end of the growth may be seen projecting below the free margin of the soft palate. When the growth is not so large as to project in this way, it can be seen on posterior rhinoscopy as a pale or dark-red rounded tumour, more or less filling the nasopharynx. On anterior rhinoscopy, nothing of note may be detected in the early stages ; later on, however, pus and projections of the tumour may be seen in the nasal cavities. On palpation of the nasopharynx, the growth is felt to be immobile and of very firm consistence.

DIAGNOSIS.—This is not difficult in typical cases, though the condition has to be differentiated from a fibromucous polypus ; but the red colour, the immobility and the firmer consistence of the tumour all serve to distinguish a nasopharyngeal fibroma from a fibromucous polypus which is of a blue colour and is freely mobile ; moreover, in the latter condition there is never a history of epistaxis. Sarcoma is the only other condition likely to be confounded with fibroma, but the former is of a much softer consistence.

PROGNOSIS.—The prognosis is always grave ; for, though cases of spontaneous involution have been met with, the ordinary course is for the tumour to progress ; and, to be successful, an operation must be complete and may accordingly be very formidable. After the age of twenty-five, the tumour grows more slowly and operation is less likely to be followed by recurrence.

TREATMENT.—If the growth is pedunculated it may be possible to remove it by means of a strong wire snare passed through the nose. As a rule, however, the base is broad and the tumour must be detached by the use of strong raspatories. Hæmorrhage is apt to be profuse, and

the entry of blood into the air-passages must be prevented by the adoption of the hanging-head (Rose) position or preliminary tracheotomy, or intratracheal ether anæsthesia may be used.

When the site of origin is the spheno-ethmoidal region, the growth may be approached by an incision along the lower margin of the orbit or outer side of the nose (Moure's operation), or through the nose after enlargement of the pyriform aperture by removal of the ascending process of the maxilla (Thomas Guthrie).

Should the base be formed by the basisphenoid, access may be gained through the mouth, the raspatories of Doyen and strong forceps of Lubet-Barbon being used to separate and twist out the tumour. Division of the hard palate was formerly practised so as to give better exposure, but the results were not satisfactory.

SIMPLE TUMOURS.

Enchondromata, exostoses, adenomata, cysts and angiomata, among the simple tumours, occur in the nasopharynx, but require no special description.

MALIGNANT TUMOURS.

Sarcomata and carcinomata occur in the nasopharynx. They give rise to nasal obstruction and hæmorrhage, while earache and deafness are frequently present. At a later stage ulceration takes place, with purulent discharge into the mouth and nose. The posterior group of cervical glands tend to become enlarged in both conditions, but this occurs at an earlier stage in carcinoma than in sarcoma.

APPEARANCES.—These vary considerably. Carcinoma may be present as a broad-based tumour similar to fibroma; but as carcinoma does not often occur before the age of thirty, a mistake in the diagnosis should not be made. Sarcoma is met with at the same age as fibroma, but it is usually softer, and the cervical glands, which may be enlarged in sarcoma, are never affected in fibroma.

DIAGNOSIS.—Catarrhal deafness, with neuralgia of the inferior division of the fifth nerve and unilateral immobility of the palate, form a triad of symptoms characteristic of this disease (Tilley). On the other hand, definite symptoms may be few or wanting. Of 46 cases studied at the Mayo Clinic, only 24 presented nasal symptoms such as obstruction, discharge, or epistaxis; 11 complained of earache, and 11 of headache or pain in the neck and jaw (G. B. New).

PROGNOSIS.—The prognosis in both these forms of malignant disease is bad.

TREATMENT.—This should be operative if there is any hope that complete removal is possible. Removal by diathermy deserves consideration, and radium may be worth a trial in sarcoma. Radium has been favourably reported upon by a number of observers.

Section IV.

THE LARYNX.

J. D. LITHGOW.

CHAPTER XXII.

ANATOMY.

THE larynx is the essential organ of voice. It consists of a series of articulated cartilages united by ligaments, acted upon by muscles, invested internally with mucous membrane, and having a special vascular, lymphatic and nerve supply. It has the form of an inverted triangular pyramidal tube (*Fig.* 81). The adult male larynx is larger than the female and proportionately longer in its antero-posterior diameter, whence appears the prominence, Adam's apple.

The larynx is situated anteriorly in the middle of the neck, lying in front of the lower part of the pharynx with which it communicates.

Above, it is firmly attached to the base of the tongue and the hyoid bone, while below it is continuous with the trachea. It has a wide range of mobility which permits of the direct examination and treatment of the respiratory tract.

The anterior and lateral aspects of the larynx are superficial, while its posterior aspect is pharyngeal. In the median plane, anteriorly, the larynx lies beneath the skin and fascia. Passing backwards it is covered in turn by the hyothyreoid and cricothyreoid muscles, the thyreoid body, the inferior thyreoid plexus of veins, and the sternohyoid muscles. These structures are noteworthy in connection with such operations as laryngotomy and tracheotomy. The common carotid arteries ascend close to the posterior borders of the larynx, while laterally and alongside the arteries run the vagus nerves and internal jugular veins.
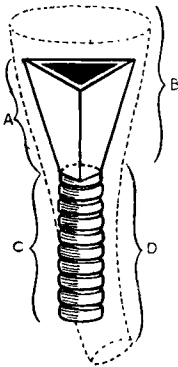
Fig. 81. — General configuration and position of larynx. (A) Larynx ; (B) Laryngopharynx ; (C) Trachea ; (D) Œsophagus.

Cartilages. - The principal cartilages are five in number: three single, the epiglottis, the thyreoid, and the cricoid ; and one paired, the ary-tenoids. Two paired cartilages of less importance are the corniculate and cuneiform cartilages of Santorini and Wrisberg.

Their form, omitting their muscular and ligamentous attachments, which are referred to separately, is briefly as follows.

Fig. 82.—Cartilage of epiglot-tis. *a*, Pits to receive lymphoid follicles.

The *epiglottis* (*Fig.* 82) is a thin leaf-like blade attached below to the receding angle of the thyreoid. It forms the anterior wall of the laryngeal vestibule. The mucous folds from its lateral borders are continued laterally towards the pharynx, and posteriorly towards the arytenoid region as the ary-epiglottic folds. Its anterior aspect is free above and attached below. The epiglottis assists in diverting the food from the entrance of the larynx. It is, however, not essential, as no ill effects follow its removal.

Fig. 83.—Thyreoid cartilage. Figure shows points of attach-ment of: (1) Epiglottis; (2) Ventricular folds; (3) Internal thyreo-arytenoid muscles; (4) Vocal folds.

The *thyreoid* cartilage (*Fig.* 83) is comparable to a half-open book. While its anterior prominent angle forms Adam's apple, its sides or alæ are prolonged posteriorly to form the superior and inferior cornua.
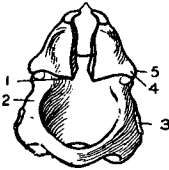
Fig. 84. — Cricoid and ary-tenoid cartilages, anterior view. (1) Vocal process of arytenoid ; (2) Cricoid ; (3) Facet on same for articulation with lower cornu of thyreoid ; (4) Muscular pro-cess of arytenoid. (5) Position of attachment of crico-arytenoid-eus lateralis to front of same.

The *cricoid* cartilage (*Figs.* 84, 85) forms the basis of the laryngeal framework. It resembles a signet ring. Its broad plate, surmounted by the arytenoid facets, is placed posteriorly ; the sides of the ring narrow down (at the expense of its upper border) to the shallow anterior portion. On the lateral aspects are facets for the inferior cornua of the thyreoid.

Fig. 85.—Cricoid and arytenoid cartilages, posterior view. (1) Area of attachment of arytenoid-eus muscle ; (2) Of crico-aryte-noideus posticus ; (3) Of median raphé of pharynx ; (4) Thyreoid facet (3 in *Fig.* 84).

The *arytenoid cartilages* (*Figs.* 84, 85, 86) are three-sided pyramids. The base of the pyramid forms the concave cricoid facet. The anterior angle forms the vocal process, and the lateral angle the muscular process. The medial surface flanks the glottis. Surmounting them are the cartilages of Santorini. The cartilages of Wrisberg lie in the ary-epiglottic folds.

Muscles.—The extrinsic muscles of the larynx are : the sternothyreoid, thyreohyoid, inferior constrictor of pharynx and stylopharyngeus. To what extent these have a function proper to the larynx is doubtful, but the inferior constrictor of the pharynx is probably auxiliary to the cricothyreoid. (*Figs.* 87, 88.)

The intrinsic muscles, of which the arytenoideus alone is unpaired, may be physiologically grouped as follows :—

Openers of the glottis : Posterior crico-arytenoid muscles.
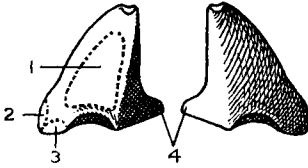
Fig. 86.—Arytenoid cartilages (enlarged), posterior view. (1) Arytenoideus muscle ; (2) Crico - arytenoideus lateralis ; (3) Crico-arytenoideus posticus; (4) Processus vocalis.

Closers of the glottis : Lateral crico-arytenoid muscles ; arytenoideus (transverse and oblique) ; thyreo-arytenoids. These muscles also diminish the elasticity or tension of the vocal cords on phonation. Cricothyreoids ; these muscles also increase the elasticity or tension of the vocal cord on phonation.

In order to appreciate the significance of an abnormal position of the vocal cord, a clear conception is necessary both of the potential individual action of each muscle concerned, as well as of its associate-action.
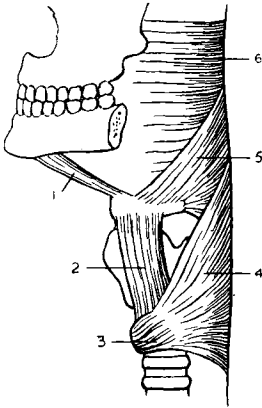
Fig. 87.—Muscular attachments of larynx, side view. (1) Anterior belly of digastric ; (2) Thyreohyoid ; (4, 5, 6) Inferior, middle and superior constrictors of pharynx.
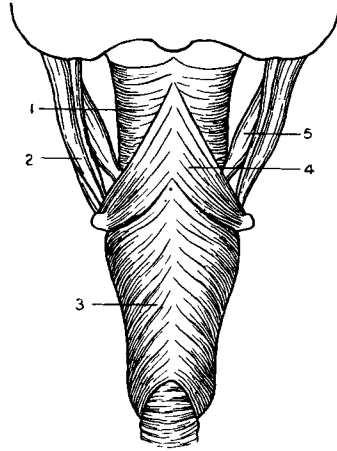
Fig. 88.—Muscular attachments of larynx, posterior view. (1) Superior constrictor of pharynx ; (2) Stylohyoid ; (3 and 4) Inferior and middle constrictors of pharynx; (5) Posterior belly of digastric.

The *posterior crico-arytenoid* (*Figs.* 89, 90) arises from the posterior surface of the cricoid cartilage : the fibres converge upwards and laterally to their tendinous insertion into the posterior aspect of the muscular process of the arytenoid cartilage (*see Fig.* 86). Its action is to open the glottis. When the muscle contracts it draws the muscular process

of the arytenoid cartilage backwards ; the vocal process passes laterally ; at the same time a gliding movement is imparted to the cartilage as a whole.

Figs. 89, 90.—To show action of posterior crico-arytenoideus muscle (diagrammatic). In *Fig.* 89 the muscle (4) is at rest, the vocal process (2) is pointing medially, the muscular process (3) lies farther to the side, and the vocal cords (1) are only slightly separated. In *Fig.* 90 the muscles are contracted, the conditions are reversed, and the glottis is widely open.
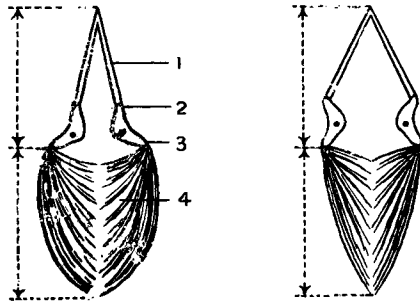
The *lateral crico-arytenoid* muscle (*Fig.* 91) arises from the superior border of the cricoid cartilage and runs obliquely backwards and upwards to its insertion into the front of the muscular process of the arytenoid.
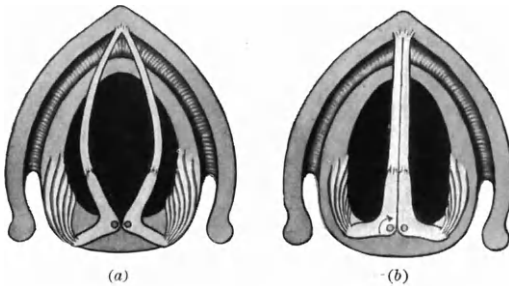
Fig. 91.—Showing action of crico-arytenoideus lateralis muscle. (*a*) The muscle at rest—the glottis is open and the vocal processes are separated (note the posterior approximation of the arytenoids due to the action of the arytenoideus) ; (*b*) The muscle in action—the vocal processes are approximated and the glottis is closed.

(*a*)   (*b*)

It is the opponent of the posterior crico-arytenoid. Its action is to assist in closing the glottis ; this is brought about by the rotation of the muscular process forwards, and of the vocal process medially.

The *arytenoideus muscle* : This median and unpaired muscle arises from, and is inserted into, the hollow posterior surface of the two arytenoid cartilages. Its fibres interlace diagonally (*Fig.* 92). Its action is to assist in the closing of the glottis by approximating the arytenoid cartilages.

There is a sphincter-like arrangement of muscular fibres in the aryteno-epiglottic folds which by its contraction tends to close the vestibule of the larynx. This is called the *aryteno-epiglottideus*.

Fig. 92.—Posterior view of arytenoids showing muscular arrangement of arytenoidei.

The *cricothyreoid muscle*, which is fan·shaped, is situated in the antero-inferior part of the larynx. Arising from the inferior border and cornu of the thyreoid, its fibres converge downwards and forwards to be inserted

into the front of the cricoid, close to its fellow of the opposite side (*Figs.* 93, 94). The muscle acts by approximating the cricoid and thyreoid anteriorly, whereby the interval between the postero-superior border of the cricoid, upon which the arytenoids are situated, and the receding angle of the thyreoid, is lengthened. The vocal cord, which runs between these two points, is thus stretched (*Figs.* 95, 96). The individual effect of this is to raise the vocal pitch. Further, the muscle opposes the tendency to shortening in active contracture of the muscular constituents of the cord in phonation.
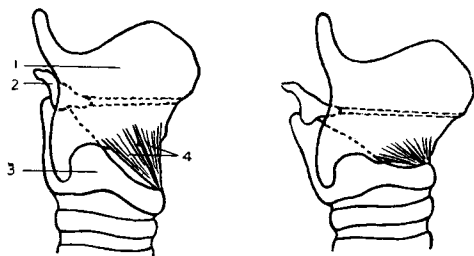
Figs. 93, 94.—Show the action of the cricothyreoid muscles, *Fig.* 93 at rest, *Fig.* 94 in action. (1) Thyreoid cartilage; (2) Arytenoid; (3) Cricoid; (4) Cricothyreoid muscle. In *Fig.* 94 note the approximation of the large cartilages anteriorly by the shortening of the muscle, the backward movement of the arytenoid, and the lengthened vocal cord.

The *thyreo - arytenoid muscle*: This pair of muscles flanks the glottis and forms the bulk of the vocal cord. Its medial fibres, triangular in appearance on coronal section (*Figs.* 97, 98, 99), intrude into the split lamina formed by the lateral surface of the inferior thyreo-arytenoid ligament, to which they are firmly attached. The mucosa of the inner free edge of the ligament is glandless, and consists of a few layers of squamous epithelium applied almost directly to the ligaments. The muscular, elastic-tissue and epithelial elements constitute the vocal cord, and vibrate in phonation as one. The muscle as a whole is also a closer of the glottis.

The special muscles of phonation are the thyreo-arytenoid and its opponent the cricothyreoid. They modify the elasticity
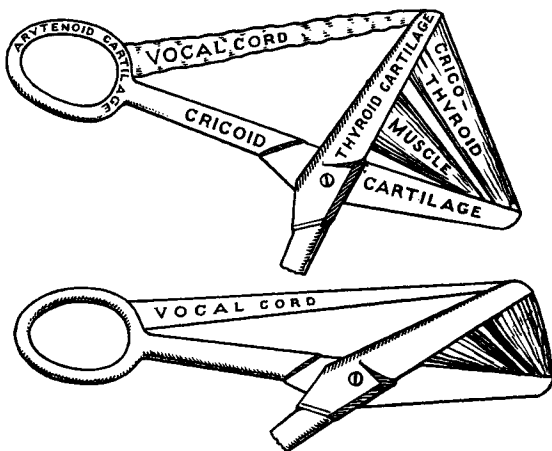
Figs. 95, 96.—Show the mechanical principle involved in *Figs.* 93, 94. Compare *Fig.* 93 with *Fig.* 95, and *Fig.* 94 with *Fig.* 96.

of the vocal cord, and so determine the pitch of the voice. The effect of the predominant contracture of the thyreo-arytenoid is to lower the pitch of the voice, while that of the cricothyreoid is to raise it. In singing, the greater expiratory effort required to swell on a note has a

tendency to sharpen the pitch ; that is compensated for by increased contracture of the thyreo-arytenoid muscle.

Ligaments.—These may be divided into the extrinsic and intrinsic ligaments. The former connect the larynx as a whole to adjoining structures, while the latter unite the individual laryngeal cartilages one to another. Some of the ligaments connect these structures directly together in the form of a synchondrosis—for example, the extrinsic cricotracheal ligament—or in the form of the capsular ligament of a joint, as in the case of the pivot-like crico
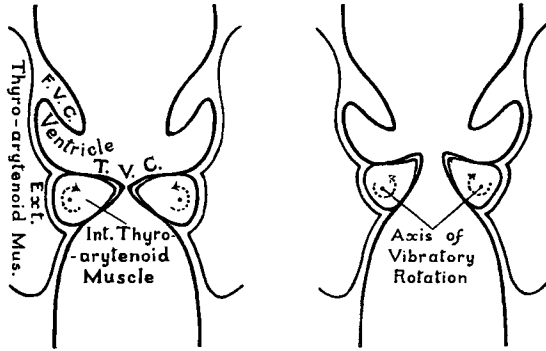
Figs. 97, 98.—Show the twisting or rotary vibration of the thyreo-arytenoids in phonation. Note the opening and closing of the glottis thereby produced. (F.V.C.) False vocal cord ; (T.V.C.) True vocal cords.

thyreoid articulation ; while others connect the cartilages across an intervening space, as does the extrinsic thyreohyoid ligament.

The ligaments are so named as to indicate which structures they connect ; it suffices, therefore, to name them and recall any point of special interest.

The *hyothyreoid ligament* is membranous in the medial portion and ligamentous laterally where it unites the superior cornu of the thyreoid to the hyoid. Where these two portions fuse, the internal laryngeal nerve and superior laryngeal artery pierce the membrane before entering the larynx. In this position the nerve is injected for local anæsthesia.

The *cricothyreoid ligament*, in addition to being the capsular ligament of the inferior cornu, forms the elastic cricothyreoid membrane. The small lymphatic gland on its surface (*see Fig.* 101) may show evidence of late induration in connection with cancer of the vocal cords. The membrane is superficial in the middle line and, through it, ready access to the subglottic region may be gained (intercricothyreotomy).

Fig. 99.—Larynx, coronal section, seen from behind in mid-glottic region. (1) Epiglottis ; (2) Ary-epiglottic fold ; (3) Ventricular fold ; (4) Vocal fold ; (5) Cricoid cartilage ; (6) Cricothyreoid membrane ; (7) Internal thyreo-arytenoid muscle ; (8) Ventricle of larynx (Morgagni) ; (9) Thyreoid cartilage. (10) Tubercle or cushion of epiglottis.

The *crico-arytenoid ligament* surrounds the base of the arytenoid,

forming a capsule sufficiently elastic to admit of a free range of mobility.

The *thyreo-epiglottic ligament* has the form of a median fibrous band.

The *superior thyreo-arytenoid ligament* is the name given to the fibrous-tissue component of the ventricular band or false vocal cord (*see Fig.* 97).

The *inferior thyreo-arytenoid ligament* forms the yellow elastic and connective-tissue elements of the true vocal cord. The predominance of elastic fibres admits of its synchronous vibration with the muscular element of the cord in phonation. The ligament is split laterally and forms a double lamina which embraces the muscle and is firmly attached to it (*Figs.* 97–100). This is of interest from the fact that the ligament is virtually an elastic epimysium to the chief component of the vocal cord. The function of the ligament is the accurate linear registration of the lips of the glottis in phonation.

Arterial Supply. — The larynx is supplied by the three following paired arteries : The superior laryngeal, a branch of the superior thyreoid, pierces the thyreohyoid membrane just in front of the superior cornu of the hyoid, where it supplies the adjacent parts ; it is accompanied by the superior laryngeal nerve. The cricothyreoid artery splits into two branches, one perforating the cricothyreoid membrane, and the other anastomosing with that of the opposite side. The inferior laryngeal artery, a branch of the inferior thyreoid, enters the larynx behind the cricothyreoid articulation, accompanied by the recurrent laryngeal nerve, and supplies the vocal cords.

Fig. 100.—Larynx, vertical median section, seen from left side. (1) Epiglottis ; (2) Adipose tissue ; (3) Thyreoid cartilage ; (4) Ventricle ; (5) Vocal cord or fold ; (6) Cricothyreoid membrane : (7, 8) Cricoid cartilage ; (9) Respiratory glottis, showing submucous position of arytenoid cartilage ; (10) Arytenoideus muscle ; (11) Ventricular fold or false vocal cord ; (12) Corniculate cartilage (Santorini) ; (13) Cuneiform cartilage (Wrisberg).

Veins. — These are the superior, middle and inferior laryngeal. They drain into the upper, middle and inferior thyreoid veins, closely following the arteries of the same name.

Lymphatics. — The system consists of a network of capillaries in the submucosa, and the lymphatic trunks into which they open. The supraglottic network of its respective side collects into several large trunks which follow the course of the superior laryngeal artery through the thyreohyoid membrane ; it drains into the superior deep cervical glands which lie on the internal jugular vein about the bifurcation of the common carotid (*Fig.* 101).

The network of the vocal cords appears both experimentally and clinically to be a comparatively *closed* system, as pigmented fluids after injection remain localized, and cancer of the cord is for some time confined to this system—there being no early involvement of the glands.

They may, however, drain indirectly through the upper group or through the cricothyreoid membrane into the small gland which lies on it. The subglottic lymphatics, somewhat less dense than the supraglottic, converge laterally to the back of the cricotracheal membrane, whence on emergence they drain into the chain of glands around the recurrent laryngeal nerve, thence into those lying on the internal jugular vein.
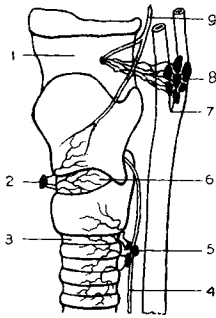
Fig. 101.—Nerves and lymphatics of larynx. (1) Hyothyreoid membrane; (2) Small lymphatic gland over front of cricothyreoid membrane, and lymphatics draining into it; (3) Cricotracheal membrane; (4) Recurrent laryngeal nerve; (5) Lower group of lymphatic glands; (6) Cricothyreoid membrane; (7) Bifurcation of common carotid artery; (8) Group of glands at bifurcation, with lymphatics draining upper region of larynx; (9) Superior laryngeal nerve, with internal (sensory mostly) and external (motor to cricothyreoid) divisions.

Nerves.—The nerves of the larynx (*Fig.* 101) are the superior laryngeal nerve and the recurrent branch of the vagus (i.e., inferior laryngeal nerve). The motor fibres have common origin with those of the glossopharyngeal and bulbar portion of the spinal accessory nerve in the nucleus ambiguus.

The *superior laryngeal* gives off an internal branch which pierces the thyreohyoid membrane and supplies with common sensibility the mucosa of the superior part of the larynx. Pain induced by the external palpation of this sensory nerve may lead to erroneous conclusions if its nature is not recognized, while subcutaneous injections of alcohol, etc., into the trunk of the nerve in this neighbourhood has proved of value in combating the intense dysphagia of phthisis laryngea. Its external branch is motor to the cricothyreoid muscle and has sensory

Fig. 102.—To show the comparative course of the right and left recurrent laryngeal nerves (back view). (1) Left recurrent laryngeal; (2) Left vagus; (3) Left common carotid artery; (4) Left subclavian artery; (5) Aorta; (6) Left bronchus; (7) Œsophagus; (8) Right bronchus; (9) Innominate artery; (10) Right subclavian artery; (11) Trachea; (12) Right vagus; (13) Right recurrent laryngeal.

Fig. 103.—To show relation of right and left recurrent laryngeal nerves to trachea (T) and œsophagus (O). (L and R) Left and right recurrent laryngeal nerves; (CV) Cervical vertebra; (TG) Thyreoid gland.

fibres which pierce the cricothyreoid membrane and supply the subglottic area (in conjunction with the recurrent). The *right recurrent laryngeal* branch loops round the subclavian artery and runs up the side of the œsophagus, passing under the inferior border of the inferior constrictor of the

pharynx to penetrate the larynx behind the cricothyreoid articulation (*Fig.* 102). That of the *left* side arises lower down, and loops round

the aorta to ascend between the œsophagus and trachea (*Fig.* 103). Each recurrent laryngeal nerve supplies the intrinsic muscles of the larynx, including sometimes the arytenoideus, and each communicates with the superior laryngeal sensory nerve supplying the subglottic region.

Fig. 104.—Pharyngeal aspect of the larynx, seen from behind. (1) Greater cornu of hyoid bone; (2) Ary-epiglottic ligament ; (3) Vocal fold (cord) ; (4) Glottis ; (5) Superior cornu of thyreoid cartilage ; (6) Sinus pyriformis ; (7) Cut through posterior wall of laryngopharynx ; (8) The 'party-wall' or anterior (cricoid) wall of the laryngopharynx ; (9) Corniculate cartilage (Santorini) ; (10) Cuneiform cartilage (Wrisberg) ; (11) Ventricular fold (false vocal cord) ; (12) Ventricle of larynx (Morgagni) ; (13) Cushion of epiglottis ; (14) Epiglottis ; (15) Lingual tonsil.

The Pharyngeal Aspect of the Larynx (Pars Laryngea). — The supraglottic and extrinsic portions of the larynx are developmentally part of the pharynx. The upper portion of the pharyngeal aspect of the larynx is situated behind and below the base of the tongue (*Fig.* 104). It comprises, from before backwards, the epiglottis with its lingual, pharyngeal and arytenoid folds of mucosa, and the superior aperture of the larynx which these latter folds enclose. The lower portion appears as two lateral pyriform diverticula of the pharynx flanking the crico-arytenoid region, or party-wall of the laryngeal pharynx, the upper and lateral wall of which is in part formed by the hyothyreoid membrane (seen in *Fig.* 104). The mucosa all over the pharyngeal aspect is loosely attached by means of an elastic submucosa, an arrangement admitting of considerable œdema. When this occurs on the lateral aspect of the ary-epiglottic folds, these may be pressed inwards to a dangerous degree, so as more or less to obliterate the vestibule (*Fig.* 105).

The Interior of the Larynx, which extends from the superior aperture to the lower border of the cricoid cartilage, may be divided from above downwards into three regions—namely, the vestibule, the glottis and the subglottic region. It is enveloped by mucosa which
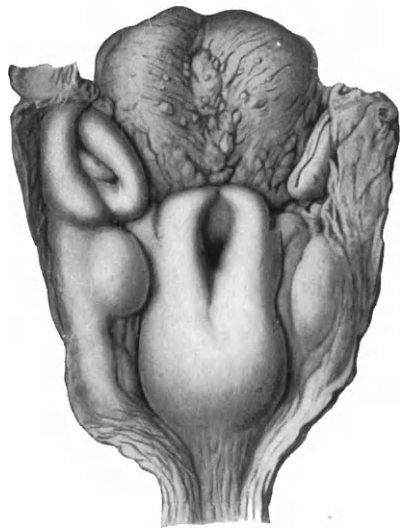
Fig. 105.—To show loose attachment of mucosa around the vestibule (acute septic œdema).

is continuous above with that of the pharynx, and below with that of the trachea.

The *superior aperture* and the *vestibule* present a funnel-shaped appearance on coronal section (*see Fig.* 99). The anterior wall of the vestibule is long and is formed by the epiglottis ; its lateral walls are formed by the slope of the ary-epiglottic folds towards the free border of the ventricular bands. The posterior wall is short and corresponds to the arytenoid cartilages and the inter-arytenoid fold. The *fibro-elastic* ventricular bands run from their anterior attachment at the receding angle of the thyreoid to the arytenoids behind. The ventricular band forms the roof of a bilateral diverticulum, the ventricle of the larynx (Morgagni), the floor being formed by the upward slope of the vocal cord. Seen on

Fig. 106.—To show form of ventricles on coronal section.

coronal section (*Fig.* 106), the ventricle with its spindle-shaped entrance is roughly triangular. From the anterior part of the ventricle there

Fig. 107.—Horizontal section of larynx through level of ventricles. (1) Arytenoideus muscle; (2) Thyreoid cartilage ; (3) Vocal fold (cord); (4) Arytenoid cartilage.

Fig. 108.—Horizontal section of larynx above ventricular band. (1) Arytenoideus muscle : (2) Arytenoid cartilage ; (3) Vocal fold (cord); (4) Appendix of ventricle ; (5) Ventricular fold (false vocal cord) ; (6) Thyreoid cartilage.

extends upwards a blind saccule, the appendix, into which open the ducts of many of the glands concerned in the lubrication of the vocal cords (*Figs.* 107, 108).

The anterior two-thirds of the *glottis* is flanked by the vocal cords, and the posterior third by the vocal processes and medial surfaces of the arytenoid cartilages. These portions are called respectively the vocal and respiratory glottis. When closed, as in phonation, the glottis is a mere chink (*Fig.* 109) ; but when widely open, as in deep inspiration, it takes the

Fig. 109.—Glottis on phonation.
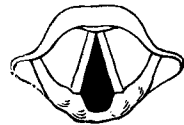
Fig. 110.—Glottis on inspiration.

form of " an heraldic lozenge whose base is truncated " (*Fig.* 110). The form of the lumen of the larynx under various conditions is noted in *Fig.* 111. The posterior wall of the glottis, being freely supplied with

sensory nerves, is a frequent source of the persistent cough in certain laryngeal affections.

The *vocal cords* are attached in front to the receding angle of the thyreoid cartilage, just below and slightly medial to the ventricular bands, and run backwards a distance of about one inch to be inserted into the vocal processes of the arytenoid cartilages (*see Figs*. 99, 100). Physiologically the term vocal cord includes the epithelium-covered free margin, the inferior thyreo-arytenoid ligament, and the internal thyreo-arytenoid muscle which flanks it.

The *subglottic region* of the larynx, as seen on coronal section, is in the form of an inverted funnel : the sides are formed by the sloping cricothyreoid ligament, and its apex by the incurving of the vocal cords to the glottis, while its broad base is continuous with the trachea below.

Fig. 111.—The aperture of the glottis seen on coronal section in : (*a*) Deep inspiration ; (*b*) Quiet inspiration ; (*c*) Cadaveric position ; (*d*) Phonation ; (*e*) Closed glottis for chest fixation (as in striking with upper extremity), and in swallowing ; (*f*) False cord phonation (vocal strain).

Its anterior wall is formed, from above downwards, by the thyreoid cartilage, the cricothyreoid membrane and the narrow portion of the cricoid cartilage ; the posterior wall is formed entirely by the broad plate of the cricoid.

The *mucosa* and its submucous layer vary in different regions of the larynx. In such regions as are not liable to friction, the epithelium is of the columnar ciliated variety ; but this is replaced in certain portions of the vestibule and over the vocal cords, by the stratified squamous type. The mucosa of the interior of the larynx is somewhat firmly bound down to the subjacent tissue by a fibro-elastic network which contains numerous mucous glands which open on the surface of the mucosa. In the sub-glottic region, however, and surrounding the upper aperture, the laxity of this layer admits of a dangerous degree of œdematous infiltration (*see Plate XI*, 2, p. 176, and *Fig*. 105). The mucosa along the free margin of the vocal cord is represented by several layers of squamous epithelium separated from the ligaments by a few narrow, longitudinal lymphatics.

CHAPTER XXIII.

EXAMINATION. SYMPTOMATOLOGY.
GENERAL THERAPEUTICS.

INDIRECT LARYNGOSCOPY.

THEORETICAL knowledge alone will not give facility in the examination of the larynx. This will only be attained by patient and continued practice. The laryngoscope is familiar and need not be described. In addition there should be provided a tongue-cloth, a spirit-lamp and, for exceptional use, a laryngeal probe and a suitable spray containing a 5 per cent solution of cocaine.

The optical principle involved in laryngoscopy is that when a ray of light impinges on a polished surface it is reflected in the plane of incidence
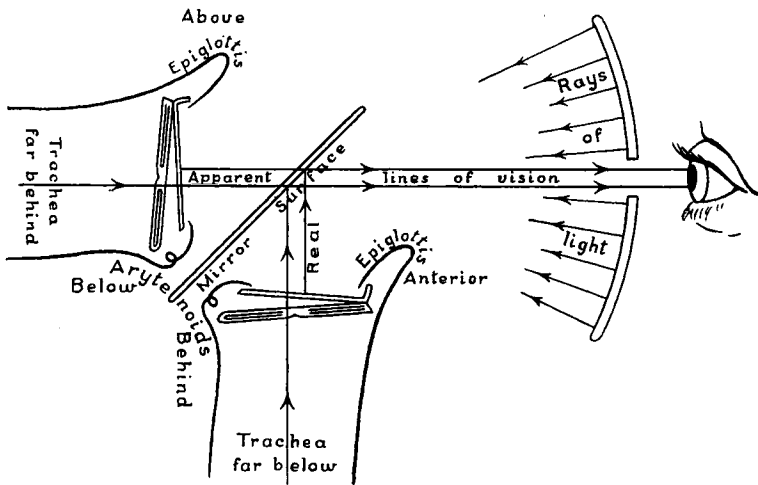
Fig. 112.—Diagrammatic scheme to illustrate optical principles involved in indirect laryngoscopy. Note the *apparent* position of the larynx behind the mirror surface, the epiglottis above, and the arytenoids below, where the right and left cords diverge. Compare this with the actual line of vision as bent to a right angle by the mirror.

at an angle equal to the angle of incidence. The application of this principle to laryngoscopy will be apparent from *Figs.* 112, 113, 114, which indicate the partial vertical, but the absence of any lateral, transposition of the laryngeal image. Thus, the anterior portion of the larynx as represented by the epiglottis appears in the upper part of the mirror,

while the posterior or arytenoid region is seen in the lower ; and between them, converging vertically from the patient's right and left to the anterior commissure, are the vocal cords of their respective sides.

Practical Considerations.—For the method of employing indirect illumination the reader is referred to p. 20. Once the frontal mirror is in position and the light properly directed on the patient's lips, the laryngeal mirror, held in the right hand after the manner of a pen, with the reflecting surface downwards and forwards, is heated over the flame of the

Fig. 113.— Shows in simplified form the same image as shown in *Fig.* 112, seen from the front.
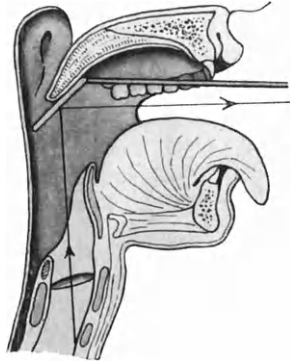
Fig. 114.—Shows actual anatomical details seen on sagittal section, for comparison with *Fig.* 112.

spirit-lamp until the moisture which has condensed on its surface has evaporated. It is now suitably warmed for introduction, but should first be tested against the ball of the left thumb. A useful method of preventing the moisture condensing on the mirror is to rub the surface with a damp cake of soap. The surface is then cleaned with a small portion of dry linen. When the surface is clean the mirror is ready for use ; no heating is necessary. The patient is requested to

Fig. 115.—Shows the practical application of *Figs.* 112-14. Compare with *Fig.* 113.

protrude his tongue as far as possible. The anterior part of the tongue is wrapped in the cloth, a portion of which should lie between that organ and the lower incisors. The tongue is now *held* firmly in position by the

left hand. The patient is requested to breathe quietly while the mirror is passed towards the back of the oropharynx, care being taken to prevent contact with the tongue, hard palate, fauces, or posterior pharyngeal wall, with merely the anterior surface of the uvula resting lightly on the back of the mirror. The light illuminates the mirror and in it is seen the laryngeal image with the cords more or less widely abducted (*Fig.* 115), moving gently laterally and medially with each inspiration and expiration, and below them the trachea ; sometimes even its bifurcation may be visible.

The patient is next requested to phonate 'eh', when the vocal cords approximate, closing the glottis. The relative mobility of the cords may further be tested by requesting the patient to laugh gently, when any difference in speed between the movement of the two cords is readily noted. To bring the anterior part of the larynx more into view the mirror should be held slightly towards the vertical, the patient's head being tilted backwards. To bring the arytenoid region more into prominence the patient's head is inclined forwards, the mirror approaching the horizontal.

When a general survey of the larynx has been made, the mirror should be withdrawn and the patient's tongue released. After a moment's pause a more detailed inspection follows, when such points as the general colour of the mucosa, whether normal or indicative of anæmia or congestion, can be made

Fig. 116.—The laryngeal image as seen in *Fig.* 115, enlarged and in more detail. (1) Lingual tonsil ; (2) Vallecula, right side ; (3) Middle glosso-epiglottic fold ; (4) Lateral glosso-epiglottic fold ; (5) Cushion of the epiglottis ; (6) Right vocal cord (fold) ; (7) False cord (ventricular fold) of same side ; (8) Ventricle between them ; (9) Upper prolongation of ventricular fold (fossa innominata) ; (10) First ring of the trachea ; (11) Sinus pyriformis ; (12) Posterior surface (muscular angle) of arytenoid cartilage ; (13) Ridge due to projection of upper posterior edge of cricoid cartilage ; (14) Interarytenoid region ; (15) Salient of corniculate cartilage (Santorini), and (16) Salient of cuneiform cartilage (Wrisberg), both enclosed in the (17) Ary-epiglottic fold ; (18) Hyoid fossa ; (19) Pharyngo-epiglottic fold of left side ; (20) Cricoid cartilage (narrow submucous surface) ; (21) Cricothyroid membrane ; (22) Subglottic and submucous view of thyroid cartilage ; (23) Epiglottis, thin edge of laryngeal aspect.

out. Different parts of the larynx may then be reviewed *seriatim*. These will be readily recognized after a glance at *Figs.* 115, 116. The actual colours must be seen to be appreciated. The vocal cords, on the other hand, are immediately recognizable by their white, pearly appearance, somewhat red-tinted in the case of professional voice-users. To complete the examination, the region of the lingual tonsil and pyriform sinuses should be inspected.

Difficulties produced by the Tongue.—Occasionally a patient is met with who cannot put out his tongue ; this makes it impossible to catch hold of it, and it must accordingly be depressed with a spatula. A common mistake with beginners is to attempt to pull out still farther a tongue which is already extruded as far as possible, or to pull the tip down and so excoriate its under surface on the sharp edges of the incisor teeth. This difficulty should be obviated by protecting the tongue from the teeth as above noted, a small portion of the cloth being inserted between the edge of the lower incisors and the under surface of the tongue, as a protection to the latter. Both these mistakes are fatal to successful laryngoscopy.

Errors in Introducing the Laryngeal Mirror.—A common mistake is to place the mirror too far forward on the soft palate ; if this is done, only the epiglottis and the back of the tongue are seen. The cause of this mistake is probably that the beginner has difficulty in seeing the uvula owing to the arching of the tongue ; in such a case he should ask the patient to say 'ah' ; this causes the palate to rise, and he should then have no difficulty in placing the mirror on the uvula.

Holding the Breath on the part of the Patient.—Some people have a tendency to hold the breath during the examination and at the same time to contract the muscles of the throat, thereby rendering it impossible to obtain a view of the larynx ; this can be overcome by making the patient breathe deeply and audibly, or else pant.

Hyperæsthesia of the Pharynx.—If this is at all marked it may make laryngoscopy exceedingly difficult, but it can generally be obviated by painting the uvula and soft palate with a 5 per cent solution of cocaine.

Overhanging Epiglottis.—If this is not very pronounced, it can generally be overcome by asking the patient to sing high-pitched 'eh' or to take sharp panting inspirations, or else to make him laugh. If these manoeuvres fail, it will be necessary, after spraying the epiglottis with a 5 per cent solution of cocaine, to hold it forward with a laryngeal probe ; the mirror is then held in the left hand, and the patient controls the tongue himself.

Direct Laryngoscopy is referred to in the section on PERORAL ENDO-SCOPY (p. 231).

SYMPTOMATOLOGY.

Interference with Phonation is one of the most common symptoms in affections of the larynx ; it may vary from slight huskiness to complete aphonia. It must be remembered, however, that marked changes in the larynx, such as certain forms of paralysis or the presence of new growths, may be unattended by alteration in the voice. The employment of the laryngoscope is imperative in all cases in which the symptom of hoarseness tends to persist. Not only may an early diagnosis of grave laryngeal disease—e.g., tubercle and malignant growth—be made by this means, but the detection of vocal-cord paralysis will provide information justifying further investigation as to the existence of aneurysm, pulmonary tubercle, intrathoracic neoplasm, or central nerve disease.

Dyspnœa due to laryngeal affections is less commonly met with and is usually a symptom of acute disease ; but where stenosis of the larynx develops gradually, remarkable tolerance is established, and breathlessness may be observed only on exertion.

Pain is not a very common symptom ; in acute catarrh, a feeling of rawness is complained of ; in malignant disease, pain shooting up to the ears is a frequent symptom ; in superficial ulceration, especially of the epiglottis, there may be severe pain and extreme dysphagia.

Cough is not a common symptom, and expectoration, when due to laryngeal disease, is usually scanty.

Hæmorrhage may occur in the larynx, but is very unusual, and is then small in quantity. A possible source of origin should be looked for elsewhere—in the trachea, lungs, nose or nasopharynx.

Difficulty in Swallowing, with or without dysphagia, comes under the notice of the laryngologist when the seat of the obstruction is referred to the cervical region. The common site in these cases is to be found either in the part of the pharynx which lies behind the cricoid cartilage (*pars laryngea pharyngis*), or immediately below this area, in the upper end of the œsophagus itself. The condition which perhaps is most frequently met with is a squamous-celled epithelioma. Though it occurs in both sexes, the majority of the patients are women, the greater number of whom are affected at or before middle life. Further, as the symptoms are often complained of over a considerable period of time, there is a tendency on the part of the physician to regard these patients as of a neurotic temperament and consequently to treat them upon wrong lines. It ought, therefore, to be borne in mind that no treatment should be adopted in these cases until a laryngoscopic examination is made, and if this fails to reveal any pathological condition, then X-ray examination with bismuth drink, followed by œsophagoscopy, should be carried out before a diagnosis is made.

GENERAL THERAPEUTICS.

Inhalations are frequently prescribed in the treatment of diseases of the larynx ; a teaspoonful of the drug which has been ordered is added to a pint of boiling water, which has been poured into a wide-mouthed quart jug ; the water is allowed to cool to about 140° F. (this will take about five minutes), and the steam is then inhaled, a towel being wrapped round the jug and the patient's head. The patient should remain in a warm room for an hour after each inhalation.

Modern developments in inhalation therapy have taken place on the Continent and elsewhere. The majority of spas and mineral bathing establishments now include what is known as an Inhalatorium, in which applications of mineral waters, oils, etc., are applied by means of a very fine spray. This is usually delivered through complicated apparatus, the object of which is to obtain as fine a spray as possible. It is used not only in diseases of the larynx, trachea and bronchi, but is also of considerable value in cases of paranasal sinusitis.

Sprays may also be ordered and, though most of the fluid remains in the pharynx, some of it undoubtedly reaches the larynx, especially if the

patient inhales deeply during the procedure. The sprays may be watery or oily ; for the latter an atomizer or aerizer must be employed.

Direct Applications to the Larynx.—Both fluids and powders may be introduced directly into the larynx under the guidance of the laryngeal mirror ; but the procedure, though easy to the expert, is not usually successful when performed by the beginner. In the case of fluids, a laryngeal syringe may be used, and it is advisable to select one which has a very small terminal orifice, so that it is easy to control the amount of fluid injected. Powders are puffed into the larynx by means of a laryngeal insufflator. The technique is similar in the two cases : the laryngeal mirror is held in the left hand, while the patient himself controls the tongue. The laryngeal syringe or insufflator is introduced by direct vision until its point appears reflected in the mirror ; the wrist is then raised, the fingers are depressed, and the tip of the instrument is thus guided over the epiglottis (*Fig.* 117). If the application has to be made to the cords, the patient should be asked to say 'ah', and at that moment the injection is made or the powder insufflated. A common mistake with beginners is not to arch the wrist sufficiently, the effect of this being that the drug falls on the posterior pharyngeal wall, and little or none enters the larynx. In cases of painful ulceration of the larynx, when powders, such as orthoform or anæsthesin, have to be applied frequently, the patient

Fig. 117.—Position of laryngeal syringe when making applications to the larynx. The laryngeal mirror, which is held in the surgeon's left hand, is not shown in the drawing.

should learn to introduce them himself. This can be done by Leduc's auto-insufflator, which consists of a glass tube bent at right angles at one end ; this end is introduced into the mouth and carried well into the pharynx ; the other end rests on a watch-glass or saucer which contains the powder to be insufflated. The patient closes his lips tightly round the tube and takes one or two sharp inspirations, thus drawing some of the powder into the larynx. In certain cases it is preferable to apply solutions of drugs rather vigorously ; for instance, in the treatment of tuberculous ulceration by lactic acid, a pledget of wool is firmly fixed in a pair of Krause's forceps and dipped in the solution, care being taken to remove any excess of fluid from the wool ; the forceps are introduced in the same way as the laryngeal syringe, and the application may be made as vigorously as is desired.

Electricity.—

*Diathermy.—*This is being used to an increasing extent in dealing with certain laryngeal affections. The nodules of lupus are frequently coagulated by diathermy. Small tumours may be destroyed and other manipulations carried out where the minimum of bleeding is required, such as the division of small webs. Diathermy is used through the direct laryngoscope under direct vision.

*Interrupted Current.—*This is used as a therapeutic agent in certain pareses of the larynx. It may be applied externally, in which case one electrode is held in the patient's hand and the other is applied to the side of the neck ; or both electrodes may be applied to the neck, one being placed on either side of the larynx. Where a maximum psychical effect is desired, an endolaryngeal electrode should be used ; this is insulated except at the extremity ; the point of the electrode, reflected in the mirror, is guided over the epiglottis and is depressed until it touches a spot between the arytenoid cartilages ; the current is then allowed to pass for a few seconds by pressing the button on the handle ; the process may be repeated two or three times at each sitting. The current should be weak at first, so that it can just be felt when the electrode is placed on the back of the hand ; if a current of this strength is well tolerated by the patient, it may gradually be increased.

The Electric Cautery is frequently used in the treatment of tuberculosis of the larynx, but it should not be employed except by those who have acquired considerable dexterity in intralaryngeal manipulations , before its use the larynx is thoroughly cocainized. In dealing with infiltrated tissues, a pointed burner is employed, and should be plunged deeply into the swollen parts ; but when granulations have to be destroyed, a flat burner will be found more suitable. When treating a tolerant patient, two or three applications may be made at one sitting, and may be repeated in a few days. If there is much pain after the use of the cautery, ice may be sucked, or a 5 per cent solution of cocaine or novocain may be sprayed into the throat. Diathermy may be employed to destroy small neoplasms within the larynx. Direct laryngoscopy has greatly facilitated this operative procedure.

*Radium and X rays.—*Radiation by gamma rays is now frequently used by means of radium or X rays for the treatment of intralaryngeal disease, particularly malignant tumours. This treatment may be carried out with or without previous surgical operation, and favourable results are reported on its use.

The Finsen Treatment by means of concentrated light has given excellent results in many cases of lupus, but is somewhat difficult of application.

*Ultra-violet Radiation.—*This is frequently used in laryngeal therapy as an adjunct to local treatment and is sometimes used in the form of local application by means of special applicators as is practised in the Finsen treatment.

Method of Inducing Anæsthesia in the Larynx.—The most satisfactory plan is that in which the throat is sprayed with 10 per cent cocaine containing a little adrenalin, and the hypopharynx is also sprayed.

After a short pause pledgets moistened in 20 per cent cocaine are applied by means of curved forceps to the upper and anterior portions of both pyriform sinuses after the manner recommended by Chevalier Jackson. This gives a block anæsthesia of the larynx. Should further anæsthesia be required the cords and subglottic region can be painted with 20 per cent cocaine on dressed probes passed through the cords.

Endolaryngeal Operations.—The successful performance of these requires much practice and a high degree of skill in endolaryngeal manipulations, and must of necessity be entrusted to the expert. These operations may be carried out by the direct or the indirect method ; the latter is more pleasant for the patient, but is less commonly employed than the direct method in adults ; in the case of young children, where a general anæsthetic is necessary, the direct plan is preferable. Under recently improved methods of direct laryngoscopy, operations by means of indirect laryngoscopy are rapidly becoming a thing of the past even in the hands of specialists. In malignant disease of the larynx the open method of operating by thyreotomy or laryngofissure is employed in cases where a cure may be expected by this partial operation, or by the direct sub-perichondrial application of radium needles ; partial or total laryngectomy is used in the more extensive cases.

General Hygiene and Internal Medication.—It is hardly necessary to emphasize the importance of attending to the general health of the patient ; and where hoarseness is complained of, it is essential to ascertain if the patient uses his voice professionally, for in that case no precaution must be omitted which will tend to preserve it. Mineral waters are of value in gouty and plethoric individuals. In catarrhal conditions of the throat, a course of treatment at Mont Dore or Eaux Bonnes may be recommended to those who can afford it. In many cases smoking must be forbidden, or restricted, and if allowed should be indulged in only out of doors. Alcohol in a concentrated form, such as spirits or the heavier wines, must also be looked upon as an irritant, while exposure to a dusty atmosphere or to extremes of temperature should be avoided. In many cases it is necessary to order rest of the voice and, occasionally, this must be absolute, not even a whisper being allowed ; any communications must then be made in writing. These conditions can only be obtained under the strict régime of a sanatorium.

CHAPTER XXIV.

ACUTE INFLAMMATIONS OF THE LARYNX.

SIMPLE ACUTE LARYNGITIS.

THE condition consists of an acute superficial catarrhal inflammation of the laryngeal mucosa.

ETIOLOGY.—The causes are : (1) *Predisposing*—gouty or rheumatic constitutions, nasal obstruction, sinusitis, habitual over-use of the voice under unsuitable conditions, inhalation of irritating vapours and tobacco smoke. (2) *Determining*—usually a chill, of which the laryngitis may be the only manifestation or a general affection of the upper respiratory tract involving the larynx. A simple indiscretion of diet or over-use of the voice may of itself induce an attack.

APPEARANCES.—The laryngoscopic appearances vary according to the stage of the disease, and occasionally with the cause of the attack (*Plate XI*, 1, 3). Associated with a general affection of the upper respiratory tract may be a uniform redness of the whole mucosa which, at a later stage, is covered by a glairy secretion which afterwards becomes purulent. Following misuse of the voice the vocal cords in particular may appear injected and swollen, the spindle-shaped appearance of the glottis on phonation (*see Fig.* 121, C, p. 209) indicating inflammatory paresis of the thyreo-arytenoid muscles (dysphonia). Sometimes—for example in influenza—there may be marked redness and swelling localized to the interarytenoid region (incessant cough), the triangular opening at the back of the glottis on attempted phonation (*see Fig.* 121, D, p. 209) indicating some infiltration of the subjacent arytenoideus muscle. Following ingestion of some hot fluid, especially in children, the epiglottis may appear dark red in colour and swollen (dysphagia). Where the case is prolonged, there may appear in the later stages dirty-coloured patches on the mucosa indicative of superficial exfoliation of the epithelium, or even small areas of ulceration. Small dark areas in the neighbourhood of the vocal cords are occasionally seen which indicate minute hæmorrhages possibly caused by coughing (acute hæmorrhagic laryngitis).

Occasionally the inflammation takes a fibrinous character—especially where such causes are at work as mustard gas or influenza (chorditis fibrinosa)—the anterior part of the cords being covered with an opaque coating deficient towards the back of the larynx, showing the real cord surface to be acutely inflamed. The appearances may vary according to the position and extent of the fibrinous deposit. In some cases small semilunar areas may be seen, somewhat recalling the mucous plaque. The rest of the larynx appears to be unaltered. The condition seldom lasts more than a few weeks. In cases where a concentrated irritant is

at work, white patches may be found on the back of the epiglottis and elsewhere on the upper aperture of the larynx, the true cords having escaped the irritant ; this is specially found when patients have been exposed to mustard gas. Opinions vary as to its pathogenesis in regard to its specific causation by influenza. In any case it is certainly not infrequently found a few days after the onset of that condition, and is accompanied by sudden hoarseness. Occasionally the irritation is so severe that subsequent necrosis may take place, involving portions of the vocal cords and subjacent muscle, with resultant permanent damage to the voice.

SYMPTOMS.—These vary according to the type and stage of the attack. They are : (1) *Constitutional* :— Chill, malaise and fever are early symptoms which may even pass off before the local condition is well established. Pain is a symptom in acute cases. (2) *Local* :—The first indication of an attack may be a sensation of tickling or discomfort in the larynx. This is followed by hoarsenesss, slight difficulty in swallowing. and possibly a dry painful cough. Expectoration, which is at first painful owing to the tenacity of scanty, clear sputum, becomes freer and more copious in quantity as the sputum assumes a somewhat yellow tinge. In adults there is seldom dyspnœa, but in children (especially when there is also adenoiditis) this may become an alarming symptom, due either to spasm of the glottis or even subglottic œdema (stridulous laryngitis, false croup). Where the last cause is not present the dyspnœa rapidly passes off.

An attack of laryngitis usually lasts a few days and spontaneously clears up. Under unfavourable conditions there is a tendency to relapse and for the condition to become chronic.

PROGNOSIS.—In children the prognosis must be guarded owing to the tendency to severe attacks of dyspnœa, while in professional voice-users there is an element of risk to the voice. Though a simple attack usually clears up spontaneously, it is advisable at least that aged persons, infants and professional voice-users should receive treatment.

TREATMENT.—*General* :—The voice should be rested in all cases, and the patient confined to one room of an equable temperature and, if the general symptoms are severe, to bed, when the administration of a diaphoretic and laxative will be helpful. The diet should be bland and not too warm. If there is irritative cough a sedative should be prescribed. A cold compress round the neck is often soothing. Children should be confined to bed from the start and, where there is a tendency to laryngeal spasm, small doses of belladonna and codeine may be employed, while an actual attack of dyspnœa may be treated by immersion in a hot bath, accompanied by the local application of cold water to the throat. The presence of tenacious sputum in children may call for the administration of an emetic. If these attacks come on only at night, and if there is no hoarseness during the day, the condition is probably due less to laryngitis than to laryngismus stridulus from inhaled secretion from the nasopharynx ; on the removal of the child's adenoids the attacks no longer occur.

Local :—During the acute stage no local treatment is needed. Inhalation of moist, warm vapour, impregnated with Friar's balsam, by means

PLATE XI

AFFECTIONS OF THE LARYNX

1. Acute simple laryngitis.

2. Chronic subglottic œdema (hypoglottic laryngitis).

3. Acute laryngitis, showing sticky secretion on cords.
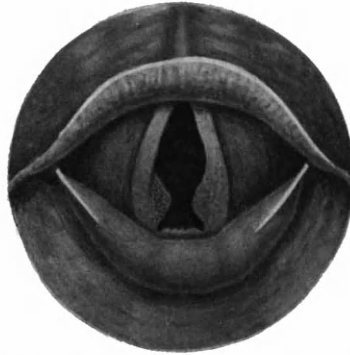
4. (Chronic) simple inflammatory pachydermia showing swelling of vocal processes

5. Tertiary syphilitic infiltration of larynx.

6. Post-syphilitic condition with deformity of epiglottis and arytenoid region.

of a suitable inhaler may be tried. For the treatment of cases showing a tendency to chronicity, the reader is referred to the section upon CHRONIC LARYNGITIS (p. 182).

PROPHYLAXIS.—Where possible the predisposing conditions should be dealt with and treated.

ACUTE SEPTIC LARYNGITIS.

The condition consists of an acute œdematous inflammation of the laryngeal mucosa and submucosa, sometimes going on to suppuration and, more rarely, necrosis of cartilage.

ETIOLOGY.—The causes are : (1) *Predisposing*—traumatism of the larynx, pre-existing laryngeal conditions such as tubercle, cancer and syphilis. (2) *Determining*—direct spread of infection from neighbouring parts, as in quinsy ; less frequently the zymotic fevers ; sudden chill may precipitate an attack.

APPEARANCES.—The laryngoscopic appearances vary according to the stage and severity of the attack. At an early stage there may be visible only . a diffuse redness of the mucosa, but later the epiglottis, the ary-epiglottic folds, ventricular bands and subglottic area may appear swollen and reddish-grey in colour, owing to the formation of a membrane, or the appearance may be localized to any one of these regions. Where there is abscess formation the region is markedly swollen and smooth, or where spontaneous evacuation has occurred a thick yellow-green discharge may be noticed.

SYMPTOMS.—The prodromal manifestations are general malaise, fever, and pain on swallowing. Later there are progressive dyspnœa and crises of suffocation which may go on to actual asphyxia ; intense lancinating pain referred to the larynx ; rapid alteration of the voice which becomes rough and aphonic ; and excessive salivation. In the event of an abscess bursting, fœtid pus may be coughed up, when the condition clears up. On the other hand, the pus may penetrate the lower respiratory passages and set up septic pneumonia.

TREATMENT.—One should be prepared to perform tracheotomy if required. For the dysphagia and dyspnœa, hot or cold compresses round the neck and local applications of cocaine and adrenalin are helpful. Where there is an abscess, an incision *under the control of vision* should be made. For severe crises of suffocation or asphyxia, tracheotomy is performed.

ACUTE ŒDEMA OF THE LARYNX.

This may be : (1) *Non-inflammatory* ; or (2) *Inflammatory*.

1. **Non-inflammatory Œdema** may be the result of a general disease, such as nephritis or cardiac disease, or it may be due to compression of the veins of the neck by a tumour or cicatricial tissue ; it may also result from angioneurotic œdema ; and it may follow the administration of potassium iodide.

The symptoms complained of are hoarseness and shortness of breath. The appearances are similar to those found in the inflammatory varieties, except that the colour of the swellings is paler.

12

TREATMENT.—The condition causing the œdema must be treated as well as the complication in the larynx. If the laryngeal symptoms are marked, scarification of the swollen parts may be tried ; this is done with a guarded laryngeal knife, numerous small incisions being made under the guidance of the laryngeal mirror. The preliminary application of a cocaine-adrenalin solution may in itself, however, so reduce the œdema as to render the scarification unnecessary. It may sometimes even become necessary to perform tracheotomy or intubation. For the angioneurotic variety, Strübing recommends giving the patient ice to suck, and morphine internally.

2. **Inflammatory Œdema** may be : (a) *Primary*—acute septic inflammatory œdema ; (b) *Secondary*—resulting from tubercle, syphilis, or cancer ; also from trauma, due to the impaction of a foreign body, the swallowing of scalding fluid, or the inhalation of chemical irritants.
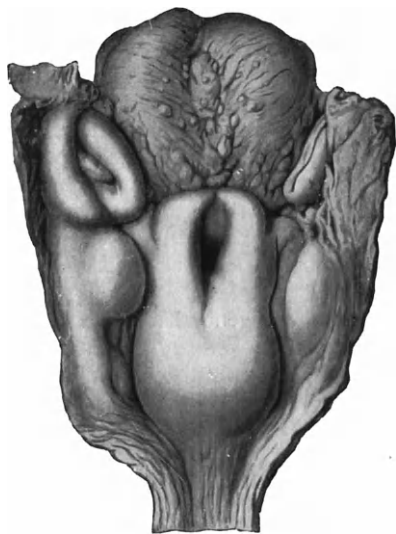
Fig. 118.— Septic œdema spreading to larynx from left tonsillar region. The condition is similar to that experimentally produced by Logan Turner, as described in the text. (From a specimen in the museum of Dr. A. Logan Turner.) (× ⅓.)

a. *Acute Septic Inflammatory Œdema.*—The etiology, pathology, and general treatment of this condition are the same as in the case of acute septic inflammations of the pharynx (p. 118), of which indeed the laryngeal inflammation is frequently a part. It is therefore necessary only to describe the appearances found in the larynx, and the special treatment to be adopted for the laryngeal complication.

b. *Secondary Œdema.*—The appearances and treatment of the primary and secondary forms of inflammatory œdema are so similar that they may be considered together.

APPEARANCES. — Whatever the cause of œdema of the larynx may be, the amount and position of the swelling are dependent on the anatomical relation of the loose submucous areolar tissue of the larynx (*Fig.* 118). Hajek and Logan Turner have investigated this subject, and have obtained similar results from their experiments. Thus, Turner found that if an injection were made between the epiglottis and the base of the tongue, the fluid filled the valleculæ and passed on to the anterior surface of the epiglottis, but was stopped by its free margin and by the pharyngo-epiglottic fold ; the latter gave way, however, under more forcible pressure, and the fluid found its way into the loose areolar tissue beneath the pyriform sinus and ary-epiglottic folds. If the ary-epiglottic folds were injected, they first became pear-shaped, but with more force the

whole pyriform sinus became filled ; if both sides were injected, the upper aperture of the larynx was completely blocked. The fluid was stopped internally at the upper margin of the false cords, while the greater part of the laryngeal surface of the epiglottis could not be injected from the ary-epiglottic folds. If the false cords were injected, the fluid was limited to them, but with greater pressure it spread to the ary-epiglottic folds. Injections made with moderate pressure in the upper surface of the true cord did not pass below the free margin of the cord, but the fluid found its way into the inferior and lateral walls of the ventricle ; with more pressure, however, it passed the edge of the cord to the subglottic region. If both cords were so injected, the lumen was much diminished.

Œdema of the larynx is usually first seen over the arytenoid cartilages and spreads along the ary-epiglottic folds. The epiglottis may early appear thickened and, as the condition advances, may appear doubled upon itself. Spread continues into the larynx and involves the false cords. These folds early become so swollen as to obscure the true cords. The obstruction is due chiefly to the swelling of the ary-epiglottic folds and the ventricular folds. The œdema may be more marked on one side than on another.

SYMPTOMS.—The symptoms produced are hoarseness and dyspnœa ; and if the œdema becomes so marked as to occlude entirely the lumen of the larynx, death from asphyxia will result.

TREATMENT.—This must be energetic in proportion to the severity of the symptoms ; in the milder cases the patient should be confined to bed in a warm room in which the air is kept moist by the use of a steam kettle ; ice may be given to suck, and cold compresses may be applied to the neck ; a spray of cocaine and adrenalin has given good results. Any causal condition higher up, such as a peritonsillar abscess, should receive prompt attention. If the œdema does not diminish, scarification of the parts should be tried, and in any case it is advisable to make preparations for immediate tracheotomy or intubation. In private practice the former should be preferred, unless skilled assistance is at hand to replace the tube in the event of its being coughed up.

DIPHTHERITIC LARYNGITIS OR CROUP.

Diphtheria may affect the larynx primarily, or it may spread downwards to that organ from the fauces.

SYMPTOMS.—The temperature rises two or three degrees, and there is at first an increase in the pulse-rate which, in uncomplicated cases, is followed after two or three days by a normal or subnormal temperature and a fall in the pulse-rate. The voice is hoarse, or may be entirely lost ; cough is also present and soon develops the characteristic metallic ring known as croupy. At first there is no dyspnœa ; but later, spasmodic attacks manifest themselves which, unlike the spasms of false croup, are not limited to the night-time. During the attacks the dyspnœa may be so severe that the child has to fight for breath : a paroxysm of coughing usually ends the seizure, and after it has passed off the respiration is not much embarrassed. If no treatment be undertaken, the attacks

increase in number and severity, and the dyspnœa becomes permanent ; the extraordinary muscles of respiration are brought into action ; during inspiration there is recession of the intercostal spaces, the subclavicular fossæ and the epigastrium ; cyanosis is marked ; and there is great restlessness. Finally the child becomes too exhausted to struggle, the cyanosis is replaced by a pale livid colour, and death soon supervenes.

APPEARANCES.—As the majority of those who suffer from this disease are in the first decade of life, and most of them are between the ages of two and five, it is rarely practicable to make a laryngoscopic examination, while in the more severe cases it is hardly justifiable to attempt it ; for where a condition is suspected to be diphtheritic, it should be treated as such even in the absence of a definite diagnosis. This has already been insisted on in describing DIPHTHERIA OF THE PHARYNX (p. 116.)
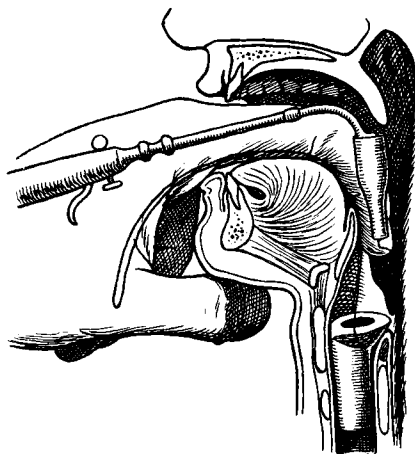
Fig. 119.—Intubation. Showing the tube just placed in position under direction of the index finger and the introducer being withdrawn. Note the string temporarily attached to the cannula.

In adults the appearances found are those of an acute laryngitis, accompanied by the presence of a false membrane ; there may, however, be extensive formation of membrane without any severe dyspnœa, as there is much more breathing-space in adults than in children.

DIAGNOSIS.—This may be difficult in children, but if there is any suspicious exudation on the pharynx, diphtheria may almost certainly be diagnosed ; where, however, there is a history of repeated previous attacks, the condition is probably spasmodic laryngitis. Laryngismus stridulus is another affection (*see* p. 201) which is sometimes mistaken for diphtheria ; but as it is rarely met with in children over two years of age, as there is no pyrexia and as the patient is usually fairly well between the attacks of spasm, it should be possible to differentiate between these conditions.

PROGNOSIS.—The prognosis is grave, the death-rate being higher than in cases of faucial diphtheria.

TREATMENT.—The general treatment of diphtheria must be carried out, but it is not discussed here. It is also advisable to place the patient at once in an atmosphere of steam. Dr. C. B. Ker did not approve of its use in conjunction with a tent, as this hindered the circulation of air, but advised that two or three croup kettles should be kept working at once, and in this way sufficient steam is supplied without the aid of a tent. Hot fomentations applied frequently to the throat also give relief. The indications for operative interference depend largely on whether the patient is treated at home or in a hospital, for in the former case, if there is definite dyspnœa, or if there has been one severe paroxysm of coughing, it is not safe to leave him without performing tracheotomy or intubation (*Fig.* 119). Tracheotomy is preferable, unless skilled aid is immediately forthcoming to replace the intubation tube in the event of its being coughed up. In hospital there is no need to operate until, or unless, the dyspnœa is very severe, and then intubation is generally performed, though, in case of failure, the instruments for tracheotomy are always kept at hand. However severe the dyspnœa may be, operative interference should not be resorted to until the effect of steam has been tried, if only for a few minutes.

CHAPTER XXV.

CHRONIC INFLAMMATIONS OF THE LARYNX.

CHRONIC LARYNGITIS.

ETIOLOGY.—The causes of chronic laryngitis are the same as those of the acute affection ; indeed, repeated attacks of the latter frequently result in chronic inflammation. Chronic laryngitis may, however, come on gradually, and in such cases the most common causes are excessive or faulty use of the voice—especially if used during the period of hoarseness of an ordinary cold—abuse of alcohol and tobacco, chronic nasal obstruction, dusty atmosphere, or, more rarely, suppuration in the paranasal sinuses ; while gouty or rheumatic patients are probably more susceptible than others.

SYMPTOMS.—The symptoms are huskiness, which is generally worse in the morning ; a feeling of dryness or irritation in the throat ; a frequent desire to clear the throat ; and often an irritable cough, which may be accompanied by the expectoration of pellets of mucus.

APPEARANCES.—Laryngeal changes vary considerably; the following types may be recognized : (1) *Catarrhal* ; (2) *Hypertrophic* ; (3) *Atrophic*.

1. *Chronic Catarrhal Laryngitis.*—In this variety there is increased redness of the parts, most noticeable on the vocal cords ; there is also increased secretion which sometimes forms bands across the cords, but there is no pronounced thickening of the tissues. On phonation, some degree of adductor paresis may generally be observed.

2. *Chronic Hypertrophic Laryngitis.*—In this variety, in addition to redness there is also hypertrophy of the tissues ; in some cases the enlargement is general, in others the hyperplasia is limited to the vocal cords, or to the ventricular bands ; the latter may become so large as to hide entirely the true cords. The hypertrophy may also be subglottic ; this condition is known as chorditis vocalis hypertrophica inferior (*see Plate XI*, 2, p. 176), and some of the cases are of the nature of scleroma ; but these are very rarely met with in this country.

3. *Chronic Atrophic Laryngitis.*—This form is described under the heading 'Laryngitis Sicca' (p. 183).

DIAGNOSIS.—Great caution should be exercised before making a diagnosis of simple chronic laryngitis, as it must be remembered that the symptoms of this disease may resemble the early symptoms of tuberculosis or cancer of the larynx, especially in those cases where the condition is unilateral. The differential diagnosis is fully discussed under TUBERCULOSIS and CANCER OF THE LARYNX (pp. 189 and 215).

TREATMENT.—Before beginning the local treatment of chronic laryngitis. it is necessary to emphasize the importance of rest of the voice, especially

in the case of individuals who use their voices professionally ; and it must not be forgotten that faulty voice production, as well as over-use or straining of the voice, predisposes to laryngitis in such persons. Any errors in this direction must therefore be rectified when work is resumed ; the technical details of this are, however, a question rather for the teacher of singing or elocution than for the physician. Where there has been over-indulgence in alcohol or tobacco, these must be at least controlled or temporarily interdicted, while avoidance of any dust-laden atmosphere is also important ; in gouty or rheumatic subjects, or in persons whose general health is below par, appropriate general treatment must not be neglected. In obstinate cases, where the patient can afford it, a course of treatment at some spa may be recommended, such as Mont Dore, Aix-les-Bains and Cauterets on the Continent, or Harrogate in our own country. In all of these health resorts there are special facilities for treating throat affections. While high altitudes are helpful, the atmosphere of the sea coast is decidedly unfavourable to this class of case.

Local Treatment.—Inhalations are of value, and one of the best is oil of pine. Where there is much secretion, the inhalation of nascent chloride of ammonium is distinctly beneficial. Direct applications to the larynx may also be made, either by the patient himself, or prefer-ably by the physician with a laryngeal syringe or by painting with a brush or with a dressed probe. The remedies which are most useful when applied by a spray are tannin, chloride of zinc, and perchloride of iron. The nozzle of the spray should be introduced well back in the throat, and the patient should inspire deeply. Direct applications by the laryngeal syringe or swab are, however, more serviceable for obstinate cases, and solutions of protargol or of silver nitrate are perhaps of most value, though Mandl's solution, or chloride of zinc, may be similarly employed. In cases where there is noticeable adductor paresis, gentle massage to the neck is indicated, combined with the internal administra-tion of strychnine ; and where there is troublesome nasal obstruction, causing mouth-breathing, this obstruction should be dealt with.

ATROPHIC LARYNGITIS, OR LARYNGITIS SICCA.

This form of chronic laryngitis requires special description.

ETIOLOGY.—This is obscure, though it may be associated with an atrophic condition of the mucous membrane of the nose and pharynx, or with suppuration in the paranasal sinuses. The condition is gener-ally met with in women, and is often observed in those who wash clothes (Porter) and are in consequence exposed to an atmosphere of steam.

APPEARANCES.—The structures of the larynx appear atrophied and unusually dry ; the openings into the ventricle of the larynx are well seen owing to the small size of the false cords ; viscid secretion can be detected on the cords, and tends to form crusts which have a dark, sometimes a bluish, tint ; the crust formation may be so extensive as to encroach on the lumen of the larynx and cause dyspnœa. The

crusting may be limited to the larynx, or it may extend downwards to the trachea and upwards into the pharynx, while in rare cases it may be associated with a smell similar to that present in ozæna ; this condition has accordingly been named by Baginsky 'ozæna laryngis'. The crusts give rise to fits of coughing, by which they are dislodged, leaving sometimes an excoriated surface below ; after expulsion of the crusts, the voice becomes temporarily less hoarse. If there is abundant crust formation, the lumen of the larynx may be seriously encroached upon, and give rise to dyspnœa.

TREATMENT.—This should be directed in the first instance towards getting rid of the crusts, which can usually be accomplished by the use of inhalations. Creasote is very serviceable for this purpose, though other inhalations may be tried. When the crusts have separated, the larynx may be sprayed with Mandl's solution and painted with bicarbonate of soda solution, while potassium iodide, given internally, is of value. The cause should be investigated.

PACHYDERMIA LARYNGIS.

This condition was originally described by Virchow from post-mortem examinations, and was first recognized clinically by B. Fränkel. It is usually found in adult males.

ETIOLOGY.—This is obscure, but it is supposed that over-indulgence in alcohol and tobacco predisposes to the condition. Pathologically it consists of a proliferation of the epithelium and great multiplication of the papillæ ; this occurs either on the true cords or in the interarytenoid region ; if on the cords, the thickening is symmetrical (*Plate XI*, 4, 176).

SYMPTOMS.—These usually consist in huskiness and sometimes in a certain amount of discomfort in the throat.

APPEARANCES.—The appearances vary with the site of the swellings ; the most common situation is on the two vocal processes—a pink elevation is then seen on both cords, with a slight crater-like excavation on the surface of one, into which the apex of the swelling on the opposite vocal process fits on phonation. In other cases, symmetrical pink swellings are found at the junction of the anterior and middle thirds of the cords ; in this situation there is usually no hollow on either side (*see Fig.* 120). A third situation is the interarytenoid region. When the pachydermia is in this position, a smooth projection is seen, grey in colour but tinged with pink ; this may be confounded with the interarytenoid tumour found in phthisis, but it should not be difficult to distinguish the two conditions, for the latter is pink in colour and has an irregular surface.

SINGERS' NODULES.

This condition consists of a hyperplasia of the epithelium of the free edge of the vocal cords, usually at the junction of the anterior and middle thirds. The condition is almost exclusively confined to professional voice-users. It is much more frequent in women than in men. This is not an isolated condition but the result of chronic irritation of the larynx,

the chief cause being misuse of the voice while subject to slight inflammation, or misuse while in an overstrained condition. While the exact mode of production of the nodules is obscure, they are certainly associated in many cases with either a faulty method of voice production or with the excessive use of the voice. The common fault in production in these cases is that of forcing the voice after most of the respiratory air has passed out, with the probable result that the cords are pressed together in the attempt to produce more sound to compensate for the diminished expiratory blast. The irritation caused by the opposing surfaces of the cords rubbing together may account for the condition.

SYMPTOMS.—The first symptoms complained of are hoarseness and loss of staying power of the voice. Singers frequently complain of a loss of their top notes and that the timbre of the middle of the voice becomes muffled. The symptoms appear somewhat aggravated in damp weather.

APPEARANCES.—Laryngoscopically (*Fig.* 120) there appear two pinkish or pearly projections on the free margin of one or both cords about the middle of the membranous portion. Occasionally there may be present only one nodule, which, on phonation, appears to indent the opposite cord. These nodules are sometimes obscured by the presence of stringy mucus. The absence of changes in the adjacent portion of the cord, and its free mobility, suffice to exclude any suggestion of tubercle or malignant disease.

PROGNOSIS.—Except for the voice the condition is not serious.

Fig. 120.—Chorditis tuberosa or singers' nodules.

TREATMENT.—The first essential is complete rest of the voice, certainly for some weeks. This alone may result in a cure. The question of further treatment on these lines resolves itself into the re-education of the voice. Any intercurrent affections of the nasopharynx and pharynx should be treated ; but not until these measures have been given a fair trial should the removal of the growths be thought of. The latter procedure is best performed by means of a special laryngeal punch. While an immediate alleviation of the symptoms usually results from the operation, a guarded prognosis should be given, as occasionally the voice is not improved, but even made worse, by interference. Further, unless the causal conditions be attended to, the growths may return.

These conditions are further considered under the special section on VOCAL DISABILITIES OF SINGERS, p. 211.

KERATOSIS OF THE LARYNX (Keratosis Laryngis Circumscripta).

Keratosis of the larynx is a condition of extreme rarity. Cases have been observed by Juffinger, O. Chiari, Fein, Logan Turner, and Porter, among others. The onset is slow, and hoarseness is usually the only symptom. The appearances observed are of a patch or patches, chalky

or snowy-white in colour, with a rough surface presenting frequently a number of spicules. They are generally situated on one or both cords. On microscopic examination, the tissue is found to consist of layers of cornified epithelium, underlying which are columnar-shaped and squamous epithelial cells. Great care should be taken to differentiate this condition from early epithelioma of the vocal cord. Treatment has been successful when the overgrowth has been mechanically removed, while painting with a 10 per cent alcoholic solution of salicylic acid has also proved efficacious.

PERICHONDRITIS OF THE LARYNX.

Perichondritis very rarely occurs as a primary affection of the larynx; it is nearly always secondary, the most common causes being syphilis, tubercle, cancer of the larynx, or trauma either from cut throat or other direct violence to the larynx, from the impaction of foreign bodies, or from inexpert use of X rays or of radium; it may also result from septic inflammation, and from typhoid, diphtheria and acute infectious fevers.

PATHOLOGY.—As a result of the inflammation, the perichondrium separates from the underlying cartilage, and an abscess forms, or else degenerative changes take place which result in the adhesive perichondritis first described by Semon, and which produce thickening of the affected cartilage. If an abscess forms, it may burst externally, or into the larynx, according to its site. In either case it continues to discharge until the necrosed cartilage is exfoliated ; healing may then take place, but is usually followed by marked deformity, and stenosis of the larynx often results. It is rare for more than one cartilage to be involved, and the arytenoid cartilages are those most frequently affected. The subsequent cicatrization may result in the fixation of the vocal cord in some 'abnormal' position (i.e., neither cadaveric nor in adduction) which differs from those due to paralysis of the recurrent nerve.

SYMPTOMS.—The onset is accompanied by pain, slight fever and moderate increase in the pulse-rate ; and there is always tenderness on pressure over the affected cartilage which becomes red and swollen. If the swelling encroaches on the lumen of the larynx, the breathing becomes embarrassed, and sudden death from asphyxia may supervene. In the case of the epiglottis and of the arytenoid and cricoid cartilages, there is pain on swallowing.

APPEARANCES.—These vary with the site of the perichondritis. If the epiglottis be affected, it swells to three or four times its natural size, and assumes a characteristic turban shape. If the cricoid cartilage be involved, the swelling may be situated in the ary-epiglottic folds, on the external surface of the larynx, or in the subglottic region. If the thyreoid be affected, the swelling may be external to the larynx or submucous (*Plate XII*, 5, p. 190). If the arytenoid cartilage be the site of inflammation, it becomes strikingly red and swollen ; the vocal cord on the same side is then fixed, and the lumen of the larynx may be much diminished. Acute inflammation of the crico-arytenoid joint presents an almost identical appearance ; the swelling may occur in the course of perichondritis of

the arytenoid or cricoid cartilages, and may therefore be produced by the same conditions which set up perichondritis ; but it may also occur in the course of acute rheumatism. The inflammation results in suppuration and destruction of the joint, or else in ankylosis.

PROGNOSIS.—The prognosis depends largely on the nature of the disease which causes the complication ; it is unfavourable as regards restitution of the voice in those cases in which the movements of the cords are interfered with ; in some instances there is danger to life itself.

TREATMENT.—Absolute rest to the voice is of prime importance, so that there may be no encouragement for the inflammation to spread beyond the affected cartilage. Cold applications may be made to the neck, in the form of an ice-bag or Leiter's tubes ; ice may be given to suck, and potassium iodide prescribed. This drug should, however, be withheld where the lumen of the larynx is much encroached upon, on account of its tendency to produce œdema. If an abscess appears to have formed, the pus should be evacuated ; where the collection is external, this is of course an easy matter, but when the incision has to be made under guidance of the laryngeal mirror, the services of a specialist will be required. Should there be a suspicion that the condition is specific, energetic anti-syphilitic treatment should be begun at once. When suppuration takes place, the swelling may so seriously encroach upon the lumen of the larynx as to cause dangerous dyspnœa, necessitating tracheotomy. When healing begins, there is a great tendency for stenosis of the larynx to develop, especially in those cases where there has been suppuration, with exfoliation of cartilage. The practitioner must accordingly be on the look-out for this complication. which should be combated by the passage of Schrötter's bougies ; if the larynx becomes markedly narrow in spite of the use of these instruments, it may be necessary to perform tracheotomy, and the patient may have to wear a tube permanently. An alternative procedure is to lay open the larynx by thyreotomy, and to fashion a new lumen for the larynx, which is kept open at first by a rubber tube ; the raw area may be skin-grafted, and the larynx is closed later by a plastic operation. The operation, known as laryngostomy, has been developed specially by French authorities (Sargnon and Barlatier).

FIXATION OF THE CRICO-ARYTENOID JOINT.

Fixation of the crico-arytenoid joint is a result of inflammation of the articulation, which is due either to a local or to a general condition, and which may run an acute or a chronic course. Of all the causes producing ankylosis. perichondritis is by far the most common, but it may also be due to inflammation following on a wound involving the joint. Enteric fever, rheumatism, gout and diphtheria are additional conditions which produce ankylosis, while permanent immobility may also be produced by purely mechanical causes, such as cicatricial contraction of the mucous membrane after syphilitic and other ulcerations.

APPEARANCES.—The appearances vary, for the cord may be fixed anywhere between full abduction and full adduction ; the most common position is one slightly internal to the cadaveric. Immobility of

the arytenoid cartilage may also be due to luxation of the joint, in which case there is marked deformity ; the condition was first described by B. Fränkel.

DIAGNOSIS.—The diagnosis may be very difficult, and it may be impossible to distinguish between ankylosis and recurrent paralysis ; but the presence of tumefaction at the base of the arytenoid process is, as Semon pointed out, suggestive of ankylosis ; and in the latter condition the arytenoid cartilage is fixed, while in recurrent paralysis it moves slightly on phonation.

TREATMENT.—In early cases some good may result from methodical dilatation by bougies ; but when the breathing is not embarrassed, it is wiser to abstain from treatment. When there is danger to life from asphyxia, tracheotomy may have to be performed. Where the condition is likely to be permanent, some operation may be carried out to enlarge the laryngeal airway. This may take the form of 'cordectomy', after the method of Chevalier Jackson, who recommends that one vocal cord should be removed with punch forceps, or the larynx may be opened in the mid-line and the vocal cords transplanted so that an adequate opening is provided.

CHAPTER XXVI.

CHRONIC INFECTIVE CONDITIONS OF THE LARYNX.

TUBERCULOSIS OF THE LARYNX.

THERE are three distinct types of tuberculous affection of the larynx : (1) *Chronic tuberculosis, or phthisis laryngea* ; (2) *Acute miliary tuberculosis* ; and (3) *Lupus.*

1. PHTHISIS LARYNGEA.

This may occur as a primary affection of the larynx, but in the vast majority of cases it is associated with pulmonary tuberculosis. There can be no doubt that the condition is infectious. It is more common in the male sex than in the female, occurring especially between the years of twenty and thirty. Subjects tainted with syphilis seem to be specially susceptible.

PATHOLOGY.—The direct cause of the condition is the local deposit of Koch's bacillus, which in most cases probably takes place by direct contagion through the air-passages, either in the form of dried infected sputum, or, where the chest is already involved, by means of the patient's own sputum, which stagnates, especially towards the posterior region of the larynx or in the ventricles. Thus, the parts most frequently involved are (in order of priority and frequency) the interarytenoid fold, the vocal cords, the arytenoids, the ventricular bands and, lastly, the epiglottis. Sometimes the infection may be by means of the blood-stream or lymphatic channels. The bacilli having reached the submucous layer either directly or through the surface epithelium and mucous glands, sooner or later there appears an infiltration of the region by leucocytes ; this area may be seen, when superficial, as a small nodule under the surface. Then follows an increase of the fixed-tissue cells of the region and an aggregation of wandering connective-tissue cells, while the endothelium lining the lymph or vascular channels proliferates, and so a concentric mass of cells is created around the organisms. Later, the cellular nature of the centre becomes less evident, the nuclei losing their staining properties, and caseation commences. Here and there may be seen large giant cells. More nodules form and coalesce, and so extension takes place. In time the nodules rupture through the surface epithelium, the caseous contents are evacuated, and an ulcer is formed which extends in surface and in depth. In the later stages the process may spread to the perichondrium, causing perichondritis, denudation of the cartilages, and eventually necrosis. The crico-arytenoid joint may thus be opened into and a tuberculous arthritis be set up. Masses

of tuberculous granulation tissue may form definite tumours or tuber-
culomas which in time tend to break down and ulcerate. In the early
stages anæmia of the mucosa is often present, but this soon gives place
to congestion and swelling of the soft tissues of the larynx which may
give an appearance of œdema ; the swelling is, however, almost entirely
cellular, and there is little real œdema except in the terminal stages
associated with mixed infection and necrosis of cartilage. Happily,
under favourable conditions the lesions, instead of progressing, show a
tendency to quiescence or even cure and, instead of a process of caseation
and ulceration, there occurs a progressive formation of fibrous tissue
around the tubercles, so that the bacilli either die or at least become
encapsulated, the process becoming somewhat lupoid in character ;
where extensive regions have been affected, healing occurs with consider-
able formation of scar tissue and resultant stenosis. In many cases of
undoubted tuberculous laryngitis a permanent cure results.

SYMPTOMS.—In the presence of pulmonary disease of only slight
severity, the laryngeal symptoms proper may be recognized as depending
upon the stage of the disease and the part of the larynx specially involved.

For clinical purposes we may divide the disease into three more or less
defined stages : (1) *Stage of tubercle formation and acute congestion* ;
(2) *Stage of infiltration and ulceration* ; and (3) *A terminal stage of
perichondritis and necrosis.*

1. During the stage of tubercle formation and acute congestion, at
first there may be no laryngeal symptoms and, where the lung disease is
of very slight severity, the patient may appear perfectly healthy, while
undoubted tuberculosis is established in the larynx. It is only when
the advancing pulmonary condition begins to tell on the general health
that the state of the larynx is discovered. *In all cases suggestive of lung
disease an early laryngoscopy should be made.* Among the symptoms
presumptive of an imminent laryngeal involvement, in such a case, are
frequent attacks of hoarseness ; when this is accompanied by periods
of dysphagia for which there is no evident pharyngeal cause the
probability here is very strong. In the absence of sputum from the
lungs there is seldom much cough or expectoration ; but if there be
cough in such a case it is usually only present at night, and is irritative
in nature.

The *laryngoscopic examination* may show little more than acute catarrh ;
at other times there appears a red irregular swelling of the interarytenoid
mucosa, or a pale papillary formation in the same region (*Plate XII*, 6).
In addition there may appear a thickening and roughness of *one* of the
vocal cords. The unilateral congestion contrasting with the pallor of
the surrounding mucosa is characteristic, while an appearance suggestive
of prolapse of the ventricle is sometimes noted.

2. During the stage of infiltration and ulceration the symptoms may
become more prominent. The voice has a characteristic hoarse, veiled
tone, although at times it is still unaffected ; complete aphonia is rare.
Cough is now more troublesome, and sometimes painful, but is occasionally
absent. Pain on swallowing is present when there is extensive disease
of the upper aperture of the larynx, and is of a particularly acute nature,

PLATE XII

AFFECTIONS OF THE LARYNX

1. Gumma of larynx.

2. Lupus of epiglottis (adult).

3. Tertiary syphilis of larynx, showing infiltration of arytenoid region and ulceration of cords.

4. Tuberculous infiltration of upper aperture of larynx.

5. Internal perichondritis of thyreoid.

6. Tuberculosis of larynx, showing interarytenoid swelling.

especially on swallowing fluids, and is usually referred to the ears. At other times there may be extensive intrinsic disease without any dysphagia. Dyspnœa is the exception in these cases.

On *laryngoscopic examination* three principal forms of lesion are commonly noted : Infiltration, ulceration, and tuberculomas ; these forms may exist as separate entities or be more or less blended together, and may affect any part of the larynx.

Infiltration is especially evident when the arytenoid regions are involved, two pale pyriform swellings showing in these situations ; and when the epiglottis is similarly affected a very characteristic appearance results (*Plate XII*, 4).

Ulceration is frequently seen, especially on the vocal cords (*Plate XIII*, 1). One cord alone may be involved ; it looks red, raw and irregular or serrated in outline. When ulcers occur on the infiltrated regions they present a mouse-nibbled appearance and are usually superficial (*Plate XIII*, 2).

Papillomatous vegetations may be noted springing from the interarytenoid region, and are characteristic. When small they are seldom a cause of aphonia ; at other times they form tuberculomas of such a size as almost to occlude the glottis, and cause aphonia and considerable dyspnœa.

Occasionally an infiltration-paresis of both thyreo-arytenoid muscles is evidenced by the spindle-shaped appearance of the glottis on phonation ; or one cord—say the right—may appear fixed in the cadaveric position owing to paralysis of the recurrent nerve caused by pressure of thickened pleura or glands. The appearance of one arytenoid and cord fixed in an atypical position is more suggestive of an involvement of the crico-arytenoid articulation.

3. During the terminal period of perichondritis and necrosis the symptoms are most urgent and painful. The voice has completely gone ; there is incessant, toneless cough ; spontaneous pain and dysphagia are complained of on attempted swallowing which, especially in the case of fluids, can be accomplished only with great pain and under special precautions ; semi-solids are somewhat more easily taken, but even they finally become impossible. Progressive dyspnœa is the terminal symptom ; it is accompanied by crises of suffocation, with the expectoration of quantities of purulent sputum or portions of exfoliated thyreoid cartilage. These terminal symptoms are escaped in most cases, owing to the rapid advance of the pulmonary condition inducing a more supportable end.

The *laryngoscopic examination*, where the landmarks are still recognizable in spite of the ulcerated and necrotic tissue, reveals areas of marked œdema ; thus a pear-shaped swelling may mark the position of a necrosed arytenoid cartilage, while running forwards from this are sometimes seen the remains of the vocal cord appearing as a motionless granular band ; more rarely there appears a unilateral swelling of the lateral wall of the larynx and ventricular band, denoting a similar process in connection with the thyreoid cartilage (*Plate XII*, 5). Sometimes all that is seen remaining to represent the larynx is a fungating and more or less stenosed crater.

DIAGNOSIS.—An early diagnosis is of vital importance, as it admits of timely treatment and a more favourable prognosis. A correct diagnosis is a matter of simplicity and certainty in the case of typical laryngeal lesions in association with severe lung disease. It becomes a matter of greater difficulty and uncertainty when, in association with some obscure tuberculous process, the laryngeal appearances resemble simple catarrh, syphilis, or cancer. As diagnosis may have to be considered at any stage of the disease, the question arises broadly thus : (a) This patient has undoubted pulmonary phthisis. Is the larynx involved ? (b) Pulmonary phthisis is suspected in this case. What of the larynx ? (c) The patient has some affection of the larynx. Is the condition one of phthisis laryngea ? (d) This is almost certainly a case of laryngeal phthisis, but in some respects it is suggestive of another disease. May it not be a mixed infection ? An answer to these questions will in most cases be found in the symptoms and laryngoscopic appearances above noted which are now differentially referred to.

The *voice* in phthisis laryngea is weak, hollow and painful ; in syphilis it is strong, rough and painless. Hoarseness combined with difficulty in swallowing is very characteristic of laryngeal involvement in lung cases. In lupus the voice is rarely affected. Dysphagia in phthisis laryngea is especially for fluids ; in cancer for solids ; in lupus there is no dysphagia.

There is marked *pain* in phthisis laryngea ; very little in syphilis and lupus. *Emaciation* is present in phthisis laryngea, but not in lupus, and seldom in syphilis. The *skin* is usually affected in lupus, and in syphilis it may show a rash. The *nose* in phthisis laryngea is usually healthy ; chronic laryngitis is more often attributable to post-nasal discharge ; in lupus there is often evidence of the disease in the nose. The *pharynx* in phthisis laryngea shows pallor of the soft palate with redness of the isthmus of the fauces ; in lupus the appearance is typical of the disease ; in cancer there is no change ; and in syphilis mucous plaques or even a gumma may be present.

The affected mucosa in phthisis laryngea is pale red in colour ; in syphilis, vermilion. Lupus and syphilis attack the interior of the larynx anteriorly ; phthisis, posteriorly. Syphilitic infiltrations are rapid in evolution, whereas the slow infiltration of the arytenoid region and the epiglottis together is very characteristic of tubercle. Ulcerations in phthisis laryngea are pale and superficial, with inactive edges ; in syphilis they are deep and punched out. 'Syphilis bites, tubercle nibbles'. Cancerous ulcers of the upper aperture are often raw and red, with over-grown edges, but on the vocal cords are dirty white in colour. Lupoid lesions show superficial ulceration associated with healing and cicatrization.

Vegetations in the interarytenoid region are characteristic of phthisis laryngea, but may be pachydermatous in nature, while innocent growths are found more often at the anterior part of the vocal cords. Papillomata grow from apparently unaltered mucosa, whereas the mucosa from which tuberculomas spring is seen to be diseased.

Recurrent paralysis of the left cord suggests thoracic aneurysm, whereas paralysis of the right cord is usually due to tuberculosis of the

PLATE XIII

AFFECTIONS OF THE LARYNX
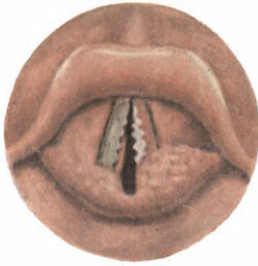
1. Tuberculosis of larynx, showing ulceration of vocal cords and infiltration of arytenoid region.

2. Tuberculosis of larynx.

3. Papilloma of larynx as seen on phonation. (On inspiration the tumour was drawn down below the glottis.)

4. Myxo angioma —so called ' fibroma '—of the left cord.
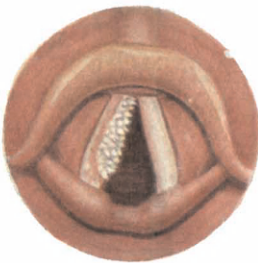
5. Intrinsic cancer affecting right vocal cord.

6. Extrinsic cancer involving arytenoid and post-cricoid regions.

pulmonary apex with thickened pleural membrane; fixation of one cord in an atypical position may suggest cancer, but may be more often due to tuberculous or former septic perichondritis.

In a certain number of cases the symptoms and appearances alone will be insufficient to ensure a confident diagnosis, and other methods may then be employed if doubt arises. The presence of pulmonary phthisis will increase the likelihood of laryngeal lesions being of a tuberculous nature, but will invalidate the use of certain tests such as von Pirquet's skin reaction. The presence of latent tubercle in any other part of the system will act similarly; but in young subjects a negative reaction to von Pirquet's test will be of great assistance in excluding the possibility of the laryngeal condition being tuberculous. Having been unable to exclude the presence of a tuberculous process, the next test will be to find out whether the laryngeal process is tuberculous. This may be done by the injection of $\frac{1}{10}$ mgrm. of old tuberculin, when the appearance of a general reaction some eight to sixteen hours afterwards will indicate the presence of an active tuberculous lesion, and a local reaction somewhat sooner in the larynx will be confirmatory of tubercle there, but will not enable one to discriminate between lupus and phthisis laryngea. The test, however, may be contra-indicated as dangerous where the lungs are severely involved. A blood-serum test may then be made of the phagocytic index, capable of indicating the presence of an active tuberculosis, but not in itself giving any definite information as to the site of infection. When the lesions are such as to admit of it, the examination microscopically of discharge or sputum will indicate the presence or absence of the tubercle bacillus. However, a single negative result will hardly exclude tuberculosis, and the examination may have to be performed repeatedly. Where there are definite growths a portion may be removed and examined, and the typical tuberculous appearance with giant-cell formation will give some help.

Somewhat similar appearances may also be found in syphilis; but the finding of tubercle bacilli in the one case or of the spirochæte in the other will clear up this point. Further information may be gained by inoculation of a guinea-pig with the discharge or a portion of removed growth. The question of syphilitic lesions may further be elucidated by the exhibition of potassium iodide, under which they usually improve rapidly, as also to a slight extent do cancerous lesions. Tuberculous lesions, on the other hand, are sometimes rendered worse by this drug, while the œdema following its use may further obscure the diagnosis. If it becomes necessary to exclude the possibility of a mixed infection such as syphilis, a Wassermann test may be employed in addition to those for tubercle.

PROGNOSIS.—A favourable prognosis largely depends upon an early diagnosis and the absence of extrinsic lesions and dysphagia. In recent years, with improved methods of diagnosis and treatment, the prognosis of phthisis laryngea has distinctly improved. Those in comfortable circumstances have a more favourable outlook. The prognosis is intimately connected with that of the associated lung condition. Where the laryngeal lesions are localized to some portion of the larynx which

can be removed, such as the free portion of the epiglottis, the prognosis is more favourable. Pregnancy has a very unfavourable influence on the progress of the case. The presence of a mixed infection, such as syphilis, renders the prognosis much more grave, in part owing to the unfavourable reaction of the tuberculous lesions to antisyphilitic remedies. During the first and second stages the disease may often be completely cured, if suitably treated, while in the first stage the larynx may entirely return to normal within a few months. During the second stage a cure can only be expected after a prolonged period of treatment, and may be followed by a degree of stenosis. In the third stage it is rare that a cure results, and the viability of the patient is seldom more than two or three years. Although in most cases death is due to the associated pulmonary disease, in some cases the laryngeal condition alone brings about the fatal termination.

TREATMENT.—

Prophylaxis.—In pulmonary disease, the causes of acute and chronic laryngitis (pp. 175 and 182) should be obviated where possible. Nasal obstructions, paranasal sinus suppuration, adenoid vegetations and enlarged and possibly tuberculous tonsils should be dealt with. The use of an intratracheal injection of a 5 per cent solution of menthol in paroleine in cases of pulmonary phthisis will do much to prevent the incidence of a tuberculous infection of the larynx (Seymour Jones's auto-inhaler may be used for this purpose). The sanitation, segregation and treatment of tubercle 'carriers' are of importance.

The earlier the treatment is instituted, the greater the probability of success. *Therefore in all cases of pulmonary phthisis do not wait for subjective laryngeal symptoms, but look for objective signs.*

The treatment of the laryngeal condition is inseparably connected with that of the lungs, but only brief reference can be made to the latter.

General Treatment.—General treatment is essentially that of the lung infection which is the underlying cause, and the addition of sanatorium treatment is strongly advised wherever possible, as the routine of a well-organized institution is one of the most potent factors for progress in many cases. Many forms of treatment have been advised for tuberculosis and no account of these need be given here, but certain recent advances in treatment have a definite bearing upon tuberculosis as it affects the larynx. Of these, immobilization of the lung by artificial pneumothorax, with or without phrenic avulsion, is one of the most important recent additions to the means at our disposal for combating this disease. Injections of gold salts are giving good results according to recent information, particularly in reducing the amount of sputum. Artificial sunlight, although still the subject of controversy, is beneficial in a great many cases.

The question of tuberculin therapy is still controversial, but as the results are somewhat encouraging, the method may with all reserve be indicated. The general principle is to keep the patient constantly under a comparatively small dose of tuberculin, fairly uniform in amount, but tending from time to time to increase, and thus to arrive at a gradual immunization. The treatment should not be started without provision for its continuation.

The preparation employed is a standard dilution of Koch's tuberculin R. in normal saline. A commencement should be made with an injection (into the substance of a muscle) of about 0·0005 mgrm. ($\frac{1}{2000}$), and the doses progressively increased for a period of at least six months to about 0·005 mgrm. ($\frac{1}{200}$), while the length of the inter-dose periods extends from one week at the start to some four weeks at the finish.

Patients should live in an atmosphere as free from dust as possible and at not too great an altitude ; these conditions can seldom be attained without a degree of moisture, which is, however, quite suitable for the larynx. But more pressing lung indications may demand a high altitude and dry air. Laryngeal cases should avoid the seaside. Hot or spiced foods should be avoided, and bland drinks preferred to spirits, etc.

A combination of general and local treatment may be tried. The method of Pfannenstill consists in the internal administration of sodium iodide in association with the local application of peroxide of hydrogen. Iodine is liberated locally and acts on the organisms.

Local Treatment.—This varies according as the indications for it are primarily subjective or objective. It may be either passive or active in nature ; thus, according to its degree of activity, medicinal, chemical, or surgical. For most of the subjective and objective indications of *the first and second periods*, and for the complete cure of phthisis laryngea, there is one outstanding rule for treatment—*rest the voice*. The ideal is absolute rest of the voice, the patient carrying a pencil and writing-pad always with him. This is possible, as a rule, only under sanatorium conditions ; where it cannot be attained, the patient should be restricted to the whispering voice. According to the state of the larynx (with lung disease of only slight severity), a cure may in some cases eventually be obtained. Cough must be repressed, voluntarily if possible but, if not, by means of heroin.

Dysphagia is one of the most troublesome symptoms and, when due to ulceration, may be alleviated by the local application of orthoform. The patient inhales the powder through a Leduc's tube about half an hour before a meal. When the difficulty in swallowing is due to ulceration of the epiglottis, especially when the disease is localized to this part, the best course is to remove the free portion of the epiglottis with a sharp-cutting punch. The infiltration of the arytenoid regions also may be a cause of dysphagia. In such cases great improvement may be expected from the use of galvano-puncture. It is advisable, however, to limit the first treatment to a single puncture ; should there be no resultant reaction one may take this as an indication that this line of procedure is unlikely to be helpful. After previous cocainization of the region, the cautery point is inserted at a white heat and retained some seconds ; after the immediate reaction passes off, great relief is experienced and a further series of punctures can be made at a second sitting. Subsequently a cure by fibrosis may occur. StClair Thomson, who has had considerable experience of this method of treatment, speaks very highly of the satisfactory results obtained thereby, and has quite abandoned the use of lactic acid in favour of galvano-puncture. Galvano-puncture is also particularly useful in the treatment of small, painful ulcers. The adoption of certain positions may assist in cases of dysphagia ; the

patient may either lie prone or supine on his bed, with the head dependent over the edge ; the food is then sucked up and swallowed more easily. Where there is intense pain on swallowing, local infiltration anæsthesia of the superior laryngeal nerves with a solution of novocain and alcohol often gives prolonged relief (*see* p. 226).   Ulcers of the vocal cords, etc., and infiltrations elsewhere have been treated by means of scraping with Heryng's curettes, and subsequently rubbing in strong solutions of lactic acid (50 per cent) or some other caustic solution ; there is now a distinct reaction against this line of treatment.   One would now be inclined to limit this method to cases of more superficial ulceration in areas such as the vocal cords.

Artificial sunlight may be used by special reflectors causing a direct application to the larynx, and enthusiastic reports are received from various workers, while in the hands of some others this method does not achieve the desired result.

The Finsen arc-light treatment as practised in Copenhagen has resulted in the cure of 53 per cent of cases (Strandberg).

Favourable results have been reported (Gainsborough) from daily intramuscular injections of benzyl cinnamic ester.

The question of tracheotomy is controversial, but the general consensus of opinion is against the use of tracheotomy except for extreme degrees of stenosis following cautery or other treatment of the larynx.   Tuberculomas, if small, may be removed with forceps *per vias naturales*, but if large may call for thyreotomy (*see* p. 217).

During the third stage also, the larynx should receive treatment.   The injections of menthol in paroleine, etc., should be continued.   Tracheotomy may be urgently required for dyspnœa due to œdema or obstructing tuberculomas, while a permanent tracheostomy may prove locally curative, or at the least add greatly to the patient's comfort.

In the great majority of cases during the terminal phase, little can be done, but the local application of cocaine and hypodermics of morphia may give some relief.

2. Acute Miliary Tuberculosis of the Larynx.

This condition is due to pharyngeal tuberculosis extending to the larynx.   The granulations affect the laryngopharynx, and principally the epiglottis.   On inspection, one sees at the early stage a swollen mucous membrane through which the tubercles appear as yellowish dots ; later on these break down and form more or less confluent ulcers with irregular torn edges.   There is always great pain, and the general state is bad.   The rapid progress of the acute tuberculosis is accompanied by marked cachexia.   The prognosis is extremely grave.   The treatment can only be palliative.

3. Lupus of the Larynx.

This is a very chronic attenuated form of laryngeal tuberculosis, histopathologically identical with, but clinically differing greatly from, phthisis laryngea.   In the vast majority of cases it is secondary to well-marked lupus of the face, nose or pharynx.   In some cases of

apparently primary lupus of the larynx there may be found ulceration of the nasal mucosa, with crusting and tubercle bacilli. The condition is contagious and occurs most frequently in young females.

SYMPTOMS.—The disease may progress for many years without any symptoms being complained of. When the vocal cords are involved, there will be a varying degree of hoarseness. At an advanced period, considerable dyspnœa may result from the cicatricial contraction which is associated with the healing of extensive lupoid lesions.

APPEARANCES.—The epiglottis is most commonly involved, especially at first. The condition is seen to spread along the aryteno-epiglottic folds, later affecting the other parts of the larynx. The affected part shows a nodular raspberry-like formation of the mucosa (*Plate XII*, 2, p. 190). At other parts there appear small ulcers extending more or less into the subjacent mucosa. The surrounding mucous membrane is usually some-what infiltrated and congested. Some parts appear to be breaking down, while in other areas there appears healing with formation of fibrous tissue.

DIAGNOSIS.—This seldom presents any difficulty, except in the absence of evident lupus elsewhere, when the condition may be suggestive of syphilis. The dryness and shallowness of the ulcers and the very slight reaction in the surrounding mucosa will, in the absence of any marked improvement under iodide of potassium and mercury, help to exclude syphilis. With a negative Wassermann reaction and a well-marked focal reaction to tuberculin one may definitely conclude that the condition is lupus. Extensive scar formation of the later stage may be hardly distinguishable from that of syphilis.

PROGNOSIS.—The disease runs a very slow course, but undoubtedly cases of cure do occur, although occasionally the condition is followed by tuberculosis of the lungs. The most common danger is the tendency to stenosis of the larynx.

TREATMENT.—The constitutional treatment is on similar lines to that of any other tuberculous process. Doses of liquor arsenicalis (commencing with 2 or 3 min. three times a day, gradually increased until upwards of 20 min. are attained) have given good results. Cod-liver oil, hypo-phosphites and syrup of iodide of iron are also helpful. Artificial light treatment is of value. Injections of tuberculin R., as indicated for phthisis laryngea (p. 195), may be tried, as also may galvano-puncture or diathermy. Where the disease is localized to the free part of the epiglottis, this may be amputated with a special punch. Ulcers may be scraped where accessible under either general or local anæsthesia, and a strong solution of lactic acid (50 per cent upwards) applied to the raw surface. Cases of slight cicatrization may call for dilatation with Schrötter's bougies. Where the stenosis is marked, an external operation may be required.

SYPHILIS OF THE LARYNX.

Syphilis of the larynx may occur as a congenital or acquired condition. The primary lesion is almost unknown. While the condition is more common in the male adult, neither sex nor age is exempt from it. Severe lesions of the larynx are not common.

PATHOLOGY.—Congenital or late hereditary syphilis of the larynx is an affection of extreme gravity. It assumes a hyperplastic form characterized by the uniformity and symmetrical nature of the infiltration. It may be associated with a similar involvement of the pharynx. There is usually no ulceration. The condition should be kept in view, as it may appear as the sole manifestation of the disease, and is only slightly influenced by the ordinary antisyphilitic remedies. During the secondary period the first evidence of syphilis is hyperæmia which may be mistaken for ordinary catarrh. This goes on to the formation of mucous papules in which there is localized increase of the surface epithelium with infiltration of leucocytes. Later on gummata may form which may either break down into ulcers or become distinct tumours (syphilomata). The ulceration may spread more deeply involving the cartilages, especially the epiglottis, when extensive necrosis may ensue. The subsequent healing and cicatrization result in extensive formation of connective tissue which, on contraction, causes marked stenosis of the larynx.

SYMPTOMS.—The prominent symptom is hoarseness. The voice is of a particularly rough timbre ; only when extensive disease is present may there be, in addition, some degree of pain. Cicatrization of the laryngeal lesions may induce marked dyspnœa.

APPEARANCES.—During the secondary period there is at first little to be made out but the general hyperæmia of the mucosa. Mucous plaques are occasionally seen on the vocal cords as white semilunar areas. The ary-epiglottic folds may be the seat of marked inflammatory œdema, causing considerable dyspnœa. The formation of gummata, which marks the transition between the secondary and tertiary period, may occur at any part of the larynx and especially on the ventricular bands and epiglottis. They appear at first as smooth swellings of the mucosa, but break down later when ulceration ensues. The floor of the ulcer has a dirty-drab colour and the edges are somewhat overhanging. Occasionally a diffuse hyperplasia of the upper aperture of the larynx, somewhat resembling that of tuberculosis, is observed. Sometimes the vocal cords may appear more or less fixed in an atypical position, due to infiltration of the muscles or involvement of the crico-arytenoid joint. (*Plates XI*, 5, 6, p. 176 and *XII*, 1, 3, p. 190.)

DIAGNOSIS.—During the early period of the secondary stage intractable laryngitis is frequent and may be mistaken for simple catarrh ; other evidence of syphilis will confirm its specific origin. Gummata are usually localized to the anterior part of the larynx (epiglottis and ventricular bands), and are somewhat circumscribed in appearance. Their rapid growth is characteristic. It may sometimes be difficult to distinguish the condition from lupus in the absence of lesions in other parts. Diagnosis will be confirmed by the absence of any reaction to tuberculin tests and the favourable reaction of the lesions to antisyphilitic treatment. It must be borne in mind that malignant growths are also temporarily improved by antisyphilitic remedies, especially iodide of potassium. Where a portion of the growth is available, the microscopic examination may be of assistance.

The condition may be very difficult to distinguish from cancer ; the rapidity of the growth is characteristic of syphilis rather than of cancer. A certain diagnosis can only be arrived at by a positive Wassermann reaction, although a certain proportion of cases of tertiary syphilis do not give this positive reaction.

PROGNOSIS.—This varies according to the stage and type of the disease. If the case is seen and treated early, the prognosis is good. There is considerable danger that gummatous processes may encroach upon the lumen of the glottis, either directly or by producing œdema, when dyspnœa may suddenly ensue. If the disease has been extensive, cicatrization may result and chronic dyspnœa supervene.

TREATMENT.—The treatment is that of syphilis generally. Where urgent symptoms of dyspnœa arise, one should avoid having recourse to tracheotomy if possible. It is better to press antisyphilitic treatment and scarify the œdematous tissue in the larynx. Local mercury inunction in the neck is very useful in this connection. In the majority of cases a favourable result is obtained by means of mercury either internally or by inunction. One should avoid instituting a course of treatment with neosalvarsan without having definitely confirmed syphilis by means of a positive Wassermann reaction. Acute laryngitis will be avoided by the patient's giving up his tobacco and spirits. Gummatous formations, if obstructing the larynx, should be removed *per vias naturales*. During the stage of cicatrization intubation may be called for, but the less active the treatment the better, until the causal condition has been efficiently dealt with.

LEPROSY AND SCLEROMA.

Leprosy and scleroma may affect the larynx, but as both of these conditions are exceedingly rarely met with in this country, no detailed description of them will be given. Leprosy is characterized by the formation of smooth or nodular infiltration and, later, slow ulceration sets in. In scleroma, smooth pale-pink swellings develop, situated on either side, below the vocal cords.

NERVOUS AFFECTIONS OF THE LARYNX.

NEUROSES OF SENSATION.

Anæsthesia.—The sensory nerve to the larynx is the superior laryngeal branch of the vagus, and paralysis of this nerve, which may be either peripheral or central, results in a varying degree of anæsthesia. The loss of sensation may be very slight or it may be complete, and the paralysis may be unilateral or bilateral. The most common cause of the latter is diphtheria ; in that disease the anæsthesia is usually associated with motor paresis of the larynx and soft palate. Unilateral paralysis may be due to apoplexy, unilateral lesions in the medulla, tumours at the base of the brain or high up in the neck, locomotor ataxia, syringomyelia and hysteria. The anæsthesia in many of these cases is associated with various forms of motor paralysis.

SYMPTOMS.—When the loss of sensation is bilateral and complete, the condition is accompanied by great danger to the patient, as particles of food are very liable to pass through the insensitive larynx and set up an inhalation pneumonia. In other cases, larger pieces of food may be caught in the larynx and threaten asphyxia. The diagnosis can only be made by palpating with a probe ; this is not perceived in the anæsthetic area, but produces cough and contraction of the parts where sensation is unimpaired. Anæsthesia of the palate, tongue, or pharynx should be looked for at the same time.

PROGNOSIS.—This depends upon the cause. Anæsthesia due to diphtheria usually passes off in five or six weeks, but when it is caused by some organic central lesion the chances of recovery are very poor.

TREATMENT.—Treatment is mainly palliative and consists in preventing food from passing into the larynx and trachea. This is best accomplished by the use of an œsophageal tube ; before introducing the food, the patient should be made to cough or phonate to see that the tube has really passed into the œsophagus. In diphtheritic cases, the interrupted current may be used. Hypodermic injections of strychnine may also be given.

In syphilis of the central nervous system iodide of potassium and mercury should be administered.

Paræsthesia, Hyperæsthesia and Neuralgia.—These symptoms are found in neurotic individuals and are especially common in women at the climacteric period. Paræsthesia, by which is meant a feeling of pricking, of heat, or of a foreign body, is also sometimes felt after a foreign body,

which was in the larynx, has passed on or has been removed. Hyperæsthesia is not uncommon in those who suffer from gout. In true cases of paræsthesia and hyperæsthesia the larynx is quite normal; accordingly, before making the diagnosis, any organic condition must be carefully excluded, and enlargement of the lingual tonsil must especially be looked for, as it is liable to cause the sensation of a foreign body. If the larynx is anæmic, the lungs should also be carefully examined, as the case may be one of incipient tuberculous infection.

TREATMENT.—The treatment should be directed towards improving the general health; regular hours, abundant diet and fresh air should be enjoined, and bodily or mental fatigue be avoided. In gouty individuals the diet should be restricted and Carlsbad salts may be ordered, while in anæmic patients iron and arsenic are indicated, combined with valerian. If pain is complained of, a menthol spray may be used, but cocaine must not be recommended in these conditions. In some cases the constant current has been found of service, the positive pole being applied to the neck. The results of treatment are, as a rule, unsatisfactory.

SPASMODIC AFFECTIONS.

Laryngismus Stridulus is a condition which is met with in children under two years of age, the majority of whom suffer also from rickets; but teething, digestive disturbances, the presence of enlarged bronchial glands, and intestinal parasites, may all be etiological factors. According to Semon and Horsley, the condition is due to irritability of the cortical adductor centres.

SYMPTOMS.—In a typical attack, the child has suddenly a few crowing inspirations, followed by a period of apnœa which may last for some seconds, the movements of respiration coming to a stop. The face assumes an expression of great terror; it is at first flushed but soon turns pale; the eyes are staring, the pupils contracted; the head is thrown back and the skin is covered with sweat. The attack ends as it began, with some stridulous inspirations. In rare cases the child dies during the seizure. The attacks may be repeated several times a day, or may occur only at long intervals. In severe cases there may be spastic contractions of the feet and hands, the thumbs being flexed into the palms and the fingers either folded over them or rigidly extended. General convulsions may also supervene.

PROGNOSIS.—The prognosis depends on the cause. It is commonly good; but, as has been stated, some patients have died from asphyxia during an attack.

DIAGNOSIS.—The diagnosis has to be made from false croup and depends on the sudden onset, the complete apnœa during the attack, and the absence of laryngeal symptoms in the free intervals.

TREATMENT.—If the patient is seen during an attack, the clothes round the neck should be loosened, and the window thrown open to permit of a free draught of air; cold water should be applied to the face and neck, and smelling salts held to the nostrils. If there is real danger of asphyxia, tracheotomy must be performed at once. The general

treatment depends on the cause and, as in the great majority of cases this is rickets, the reader should refer to a work on the practice of medicine, it being outside the scope of the present volume. It will suffice to state that the diet must be carefully regulated, and that cod-liver oil and tonic treatment should be administered. If the attacks recur frequently, bromide of potassium may be given.

Congenital Stridor of Infants.—As the name indicates, the condition is noticed immediately after birth and consists in a disagreeable croaking stridor on inspiration. Expiration, except in severe cases, is noiseless. According to the degree of stridor the sound may vary in pitch. The condition is more marked during the waking hours, though it is often present while the infant sleeps. The stridor is noticeably aggravated by excitement, when the crowing is more high-pitched. There is no altera-tion in coughing and crying. Although there is distinct inspiratory obstruction, as evidenced by retraction of the abdominal and thoracic walls, the infant does not tend to become cyanotic. The difficulty in breathing does not appear in any way to alarm the child, possibly owing to the congenital and constant nature of the affection. During the first month or so the stridor becomes more marked and then, after a some-what similar period in which there is no increase in the condition, there is gradual diminution of the symptoms, so that at the end of two years the stridor may have almost entirely passed off. For some considerable time the stridor is apt to be set up temporarily by excitement.

ETIOLOGY.—While many theories have been advanced, we may here mention some which, although possibly not wholly causal in nature, must certainly be contributory to the condition. The position taken up by John Thomson and Logan Turner, who have specially studied the subject, may be briefly summarized as follows :—

1. Owing to a late development of the cortical centres controlling respiration there results an inco-ordination in the respiratory movements.

2. There is thus a recurring sucking in of the soft structures forming the upper aperture and a consequent accentuation of the normal infantile type of larynx.

3. A similar state of affairs occurs temporarily during anæsthesia in children.

4. That the stridor is not produced in the pharynx is evident by the phonatory nature of the sound, and it is uninfluenced by any movements of the tongue or mouth, or by occlusion of the nose. In none of the fatal cases of congenital stridor was there noted any enlargement of the thymus or lymphatic glands ; whereas, in two fatal cases of stridor in infants observed by Thomson and Turner where such enlargements were found, the symptoms were not those of congenital stridor, the stridor being chiefly expiratory.

5. The presence of adenoids as a source of reflex irritation is not in their experience, a causal factor.

This view differs from that of Lack and Sutherland only in the sup-position that the deformity, although due to the indrawing of the flaccid aperture of the larynx, occurs not as a primary congenital condition, but rather as an acquired malformation owing to the inco-ordinated

respiratory movements—that is that the diaphragmatic intracostal inspiratory movements are not synchronous with those of the abducting muscles of the larynx. While these views have received much support, there are others who strenuously hold that the condition is primarily due to compression of the trachea by means of an enlarged thymus gland, and that the exacerbations as above described are only the reflex manifestation of chronic respiratory obstruction (Avellis) ; this view has in its support the fact that typical cases of congenital infantile stridor have been incidentally and permanently alleviated by surgical treatment of the enlarged thymus gland. There have also been noted cases where removal of adenoid vegetations has undoubtedly cured the condition. One must not leave out of account the small calibre of the infantile larynx, in which any untoward movements caused either by lack of co-ordination of the abductors on inspiration or by sinking in of the elastic lateral walls, or by reflex spasm of the abductor muscles, may readily produce considerable interference with respiration. Paterson and Brown Kelly have noted on direct examination of the larynx an exaggerated infantile type with a very long and tapering epiglottis whose lateral edges are bent backwards, forming an almost complete cylinder, and leaving only a narrow vertical slit posteriorly for the entrance of air.

It is only reasonable to suppose, from the many different views as to the causation of the condition, that any one of the suggested causes may contribute to it, and that congenital stridor of infants is a name given by different observers to several somewhat similar conditions in infant life.

PROGNOSIS.—The prognosis is favourable, as the condition tends to pass off before the end of the second year.

TREATMENT.—The treatment should be firstly symptomatic, and then attention should be given to any possible contributory cause, such as adenoids, enlargement of the thymus, or signs of delayed development.

Laryngeal Spasm in adults may be due to central nervous diseases such as locomotor ataxy (in which it produces the well-known laryngeal crises), or it may occur in epilepsy, tetanus, hydrophobia, tetany, or chorea ; it may result from mediastinal growths which stimulate the vagus nerves, and it may also depend on direct irritation of the larynx by foreign bodies, tumours, or the application of medicaments. The duration of the spasm varies ; it may be sufficiently prolonged to cause loss of consciousness.

SYMPTOMS.—These are similar to those found in spasm in children, but are usually less severe, though death has been recorded in cases where a growth has been gripped by the spasm of the cords.

TREATMENT.—The treatment of an attack is the same as that of laryngismus stridulus, and the general treatment depends on the exciting cause.

Rhythmic Movements and Tremor of the Vocal Cords.—Tremor of the vocal cords is not infrequently observed ; it is found in disseminated sclerosis as a form of intention tremor and is then frequently associated with paresis. Tremor has also been met with in cases of syringomyelia, paralysis agitans, chorea and hysteria.

It is more uncommon to find cases showing rhythmic continuous involuntary movements of the vocal cords, which resemble an ocular nystagmus, and are unaccompanied by paralysis. These movements are usually synchronous with contractions of some or all of the muscles which take part in the act of deglutition. There has been evidence of organic disease of the central nervous system in all the recorded cases. In only two have the movements been restricted to one side of the larynx ; one case was recorded by Scheinmann, and the other by Porter.

TREATMENT in such cases can be of little service.

Phonic Spasm is a condition met with in neurotic adults who use their voices professionally. The cords act quite normally during respiration, but when the patient attempts to speak they become firmly pressed together after a few words and no further sound can be emitted, as air cannot be forced through the glottis. The spasm ceases as soon as the endeavour to phonate is abandoned. The results of treatment are usually very unsatisfactory, but in early cases careful breathing exercises and lessons in voice production should be advised.

Mogiphonia is an affection allied to phonic spasm and was first described by B. Fränkel. It is a professional neurosis occurring in singers, teachers and clergymen. The patient finds speaking or singing at first difficult, and then impossible ; associated with this there is a feeling of pain in the neck. The ordinary conversational voice is unaffected.

Phonasthenia is a condition similar to mogiphonia, except that the fatigue of the voice is evident on any attempt to speak. The prognosis is not very good. Treatment should consist in rest, followed by massage of the neck, and also in systematic instruction in voice production.

Laryngeal Vertigo.—This is a rare affection, which nearly always occurs in men ; it was first described by Charcot. The nature of an attack is as follows : The patient is seized with a fit of coughing, during which he becomes giddy, or falls down and loses consciousness for a second or two ; he then gets up and feels quite well. Various theories have been advanced in explanation of this phenomenon, but McBride's is the one most generally accepted, i.e., that it is due to forced expiration with a closed glottis. He made experiments under these conditions, and found that the pulse became weaker, and that the sphygmographic tracing showed a rapid and continuous diminution of the up-stroke. He argues that in laryngeal vertigo " the closure of the glottis is complete, and that the whole expiratory effort is felt through the air contained in the lungs, by the alveoli, the large vessels in the thoracic cavity, and the heart itself. As a result syncope—or a tendency to syncope—is produced, and almost at the same moment the spasm of the glottis relaxes and the attack is over."

PROGNOSIS.—This is favourable.

TREATMENT.—The treatment should be directed to maintaining the general health, and to relieving the tendency to spasm by the administration of bromides.

Nervous Cough.—This is a spasmodic and frequently a barking cough, met with in young persons of both sexes, who are commonly of a neurotic

type, and in whom no affection can be detected which is associated with this symptom. The cough is generally single, but may be paroxysmal in character ; as a rule it continues throughout the day and ceases only during sleep.

TREATMENT.—The condition is not amenable to ordinary treatment. Morell Mackenzie found that the best results were obtained by sending the patient for a sea voyage. If this is impossible, large doses of bromides may be given ; or arsenic, with or without iron, may be tried.

MOTOR PARALYSIS.

Before commencing the study of this section the reader is advised to refresh his memory of the anatomical and physiological aspects of the muscular and nervous supply of the larynx (pp. 158 and 163).

Paralysis may affect either the motor or the sensory nerves, or both combined. The condition may be a complete paralysis, or may only amount to a slight paresis. It may affect either side or both sides. The condition may involve either the whole fibres of the nerve-trunk, or, for a time at least, a part of them—for example, the abductor fibres. There is an almost invariable order in which the motor fibres of the recurrent laryngeal nerves are affected. This has been enunciated by Semon in the following terms : " In all progressive organic lesions of the centres and trunks of the motor laryngeal nerves the fibres supplying the abductors of the vocal cords become involved much earlier than do the adductors. When the paralysis is confined to the adductors of the vocal cords it is almost invariably bilateral, and is due to functional changes in the central nervous system." Paralysis due to inflammatory conditions in the larynx is not considered here, this being myopathic in origin. It is referred to under ACUTE LARYNGITIS (p. 175).

FUNCTIONAL APHONIA.

ETIOLOGY.—This condition is most frequently met with in young females, but may occur in others. It may be associated with some condition of nervous shock, or it may be present in incipient phthisis. In some patients there is a degree of general neurasthenia and in others a slight catarrhal laryngitis.

SYMPTOMS.—The condition usually comes on suddenly, possibly after some extreme mental perturbation. The patient finds the voice is either completely gone, or is reduced to a whisper. This is the only symptom complained of as a rule. There is no spontaneous cough. When the patient is asked to cough she does so in the usual way. Often there may have been previous attacks which have passed off.

APPEARANCES.—On attempted phonation the cords are seen to approach towards the middle line, but the glottis is never completely closed. Sometimes there may be a large opening in the respiratory portion (*Fig.* 121, D, p. 209), and at all times there is a spindle-shaped opening left in the membranous glottis (*Fig.* 121, C). On coughing, the cords appear to come close together and, on respiration, the movements are quite normal.

If there are signs of catarrh these suggest that the condition is a myopathic paresis, in which case evidence should be sought for the usual causes of such. These are acute laryngitis, tubercle, syphilis, lead and arsenic poisoning, diphtheria, etc.

DIAGNOSIS.—The diagnosis is usually arrived at from the history, the sudden onset and the absence of any other attributable cause of the aphonia ; also from the fact that the act of coughing is not interfered with. The absence of any laryngeal change other than the paresis as mentioned will also indicate its nature. Further, the condition is always bilateral, and the absence of any abductor paresis will exclude the likelihood of its being a bilateral organic lesion (see Semon's dictum, enunciated above). The condition in a mild form is sometimes met with as a premonitory sign of phthisis and appears at an early stage when there is no other laryngeal suggestion of tuberculosis.

PROGNOSIS.—Although the condition disappears spontaneously in the majority of cases, or at the worst gradually disappears, occasionally the functional paralysis is very refractory. It may even temporarily disappear and almost instantly return again, the voice remaining aphonic as before.

TREATMENT.—As soon as it has been decided that there is no evident organic or myopathic cause for the malady, an attempt should be made to persuade the patient that the condition is purely a nervous affection and that there is no hindrance to the free use of the voice. It may be suggested that the condition which has caused the aphonia has passed off, and that the voice can now be freely used. In many cases, with a little encouragement the suggestion takes effect and, after the patient has been induced to cough once or twice and produce a sustained musical note, the voice may almost entirely return, especially if one succeeds in distracting the patient's attention momentarily from the obsession of aphonia. It may frequently be seen that patients use the voice freely, and then in a few minutes again become apparently aphonic. In such a case, therefore, there is a psychical condition, and internal faradization may be tried. After a somewhat sharp application of this remedy, a still further proportion of cases recover the voice and retain it either permanently or for a more or less prolonged period. The friends should be instructed to keep the patient talking after the doctor leaves and thus obviate the tendency to an immediate relapse into aphonia. Some authorities find it an advantage to make a local application of an astringent, such as chloride of zinc, to the larynx. This treatment does not recommend itself in the absence of any local indication, and probably acts only in virtue of the discomfort and spasm which it induces. A somewhat better effect may be obtained by faradization, without any damage to the delicate tissues of the larynx. One electrode is passed into the larynx, while the other, to which is attached a sponge, is applied to the larynx externally, preferably in the region of the cricothyreoid muscles. The general health and in the case of a female, the genital system, should be inquired into and if necessary treated. The internal administration of tonics such as syr. hypophos. co. is of advantage, especially if combined with a change of air and scene. In intractable cases Weir-Mitchell treatment may be called for.

PARALYSIS OF THE RECURRENT LARYNGEAL NERVE.

The paralysis is more commonly unilateral, but may be bilateral.

Unilateral Recurrent Paralysis.—

ETIOLOGY.—The left recurrent laryngeal nerve is more frequently affected than the right, probably owing to its longer course, the commonest cause being pressure of an aortic aneurysm. The most common causes of paralysis of the right recurrent laryngeal nerve are cancer of the œsophagus, thickening of the pleura over the apex of the right lung, and aneurysm of the innominate or right subclavian artery. Mediastinal tumours, glandular enlargements in some cases secondary to mammary cancer, and tumours of the neck may affect either nerve. Tumours of the base of the brain, hæmorrhages into the medulla, and certain progressive nervous diseases, such as locomotor ataxia, bulbar paralysis, or multiple cerebrospinal sclerosis, may also cause the condition. The recurrent laryngeal nerve may be injured or divided during operations on the neck or as the result of wounds accidentally produced. More rarely unilateral paralysis is due to diphtheria, ptomaine poisoning, influenza and plumbism.

[In regard to the last mentioned condition, compare paralysis of the radial nerve.]

SYMPTOMS.—The symptoms vary according to the site of the lesion. When it is above the region of the superior laryngeal nerve there are, in addition, symptoms pointing to paralysis of the superior laryngeal, that is, anæsthesia of the larynx and certain alterations of the voice. The lesion is, however, more commonly below the origin of the superior laryngeal, when there is no coexisting anæsthesia. Although the division of unilateral paralysis of the recurrent into three stages appears to be confirmed by experiments on animals and is usually accepted, many observers confess that they have never seen a case of incomplete paralysis that passed on to the complete stage, however well recognized these two conditions are separately as clinical entities. During the first stage ('incomplete paralysis'—abductor paresis) symptoms may be entirely absent, the condition passing unnoticed. The voice is unaltered and there is little or no dyspnœa. During the second stage ('incomplete paralysis') there may be slight dyspnœa on exertion ; and during the third stage ('complete paralysis') the tendency to dyspnœa passes off save on exertion, the voice becomes husky, and there is marked phonatory waste, considerable effort being called for in the use of the voice.

APPEARANCES.—During the first stage ('incomplete'), on phonation there is no alteration visible, but on inspiration the affected cord is seen to lie near the middle line. During the second stage ('incomplete'), on phonation there is still nothing abnormal noted, but on inspiration the affected cord is seen to be fixed in the median plane. During the third stage ('complete') (*Fig.* 121, A), the affected cord on phonation is seen fixed in the cadaveric position, i.e., midway between the position of phonation and quiet inspiration, and the arytenoid cartilage of the affected side is somewhat in front of that of the healthy side. The free edge of the cord is somewhat concave in outline and, in a case of long

standing, the cord may be somewhat atrophied, being narrower than the healthy cord. Before 'compensation' has been established, on attempted phonation, the healthy cord only reaches the median plane and the glottis is not closed. In a case of longer standing, after compensation has been established, the healthy cord on phonation is seen to cross the median plane and the glottis appears somewhat oblique and almost completely closed (*Fig.* 121, B). This may be looked upon as the fourth stage or stage of compensation.

PROGNOSIS.—While the condition in itself is not dangerous to life, the prognosis is that of the causal condition and is correspondingly serious. Should the paralysis be due to enlargement of the lymphatic glands, influenza, diphtheria, etc., or to some remediable condition, and not be of too long standing, a cure may be expected; but the vast majority of cases are due to more serious disease.

TREATMENT.—As a rule no special laryngeal treatment is called for other than that of the causal condition. When the paralysis is not due to some gross lesion of the nerve, strychnine and faradization may be of use.

Bilateral Recurrent Paralysis.—

ETIOLOGY.—While any of the diseases causing unilateral paralysis may contribute to a bilateral condition, among the more common causes are tumours of the œsophagus and mediastinum, bulbar paralysis, locomotor ataxia, multiple cerebrospinal sclerosis, cerebral syphilis, diphtheria, ptomaine poisoning, influenza and plumbism.

SYMPTOMS.—During the first two stages there may be attacks of laryngeal spasm (tabetic laryngeal crises). During the first and second stages before the paralysis is complete, there is noticed gradual and progressive respiratory dyspnœa which is much aggravated on exertion and is also present during sleep. During the third stage (complete paralysis) the respiration has become very much easier and except during excessive effort there is little or no dyspnœa, save when the patient accidentally inhales into the lungs foreign bodies, such as saliva or food. Violent attacks of dyspnœa may take place. The voice is entirely gone and the patient is unable to cough. During sleep, unless saliva be accidentally inhaled, there is little embarrassment in the respiration.

APPEARANCES.—During the first and second stages, when there is abductor paresis and paralysis, the cords on phonation are seen close to the median plane. When there is only paresis the glottis may open slightly on inspiration, but when the abductor fibres are completely paralysed the cords are seen on inspiration to be close to the middle line and tending to be drawn together, while on expiration the glottis opens slightly (*Fig.* 121, F). During the third stage, that of complete recurrent paralysis, on attempted phonation, inspiration and expiration, the cords remain fixed in the cadaveric position, i.e., midway between phonation and quiet inspiration (*Fig.* 121, E).

PROGNOSIS.—This is more serious than in the case of the unilateral condition, as a dangerous degree of dyspnœa may occur during the first or second stage, while there is a risk of inhalation pneumonia during the third stage. Where the causal condition is remediable a correspondingly less grave prognosis may be given.

TREATMENT.—General treatment applicable to the causal condition should, of course, be instituted. The patient should avoid exercise of any sort, especially during the early stages of the condition. Should acute symptoms of dyspnœa be urgent, it may be necessary to have
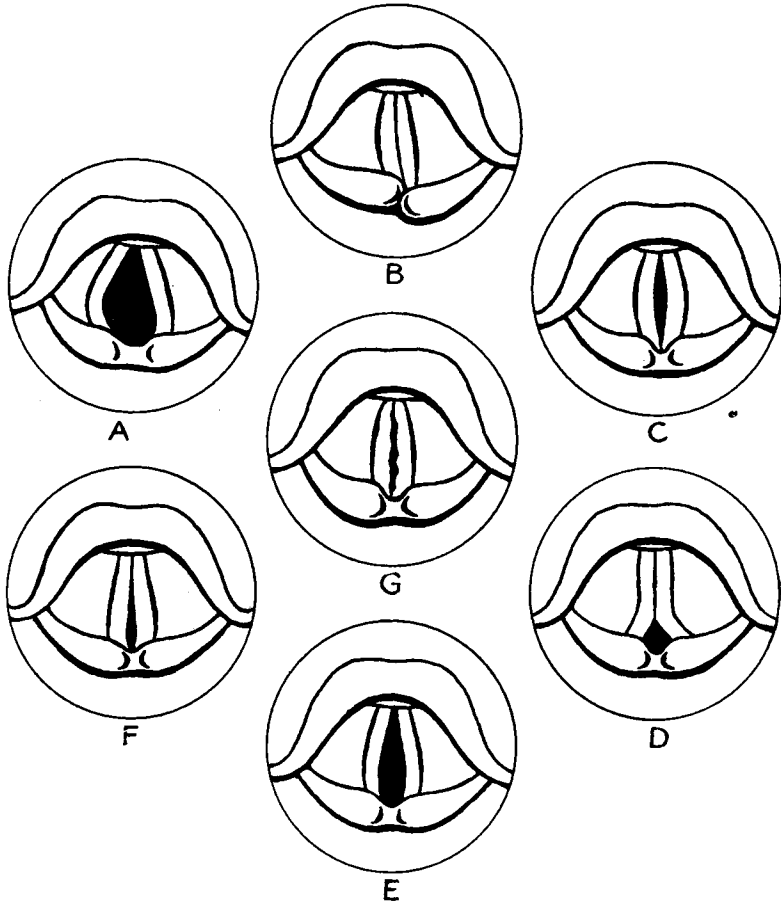
Fig. 121.—Motor paralyses of the larynx. Laryngoscopic images: (A) Complete recurrent paralysis (left)—deep inspiration ; (B) Complete recurrent paralysis (left)—old-standing case with 'compensation' by right cord on phonation ; (C) Paralysis (or paresis) of thyreoarytenoids : (D) Paralysis (or paresis) of arytenoids ; (E) Bilateral recurrent paralysis, complete—both cords are seen in the cadaveric position on *expiration*, on inspiration they are somewhat *closer* together; (F) Double abductor paralysis (bilateral recurrent paralysis—incomplete stage), on inspiration ; (G) Paralysis of cricothyreoids (superior laryngeal nerves, bilateral.

recourse to tracheotomy. Operative treatment has of late shown some promise of relief for these patients. Many operative procedures have been tried and more have been suggested. Removal of one cord by punch forceps through a laryngoscope has been practised by

14

Chevalier Jackson with a varying degree of success. This operation he has called 'cordectomy'. Apparently there is no certainty of permanent relief, but it has the merit of comparative simplicity and undoubtedly gives immediate security to the patient. 'Ventricle stripping' is a suggestion from veterinary practice. Portmann has recently described the operation for the removal of the adductor muscles in order to correct the position of adduction responsible for the dangerous dyspnœa.

Of the operative treatments suggested, however, some method of transplantation of the vocal cord seems to afford the greatest promise. This consists in mobilizing the anterior ends of the vocal cords and fixing them in such a position that sufficient airway is assured. In certain Continental clinics this is done by fixing the cords at different levels in a vertical plane. In this country successful cases have been shown by Woodman and by Hall, in which the anterior ends of the vocal cords were moved outwards and fixed in such a position that a permanent airway was provided. Measures such as these render the 'permanent low tracheotomy' unnecessary.

MYOPATHIC PARALYSIS.

Occasionally certain isolated muscles may be affected by paralysis without the whole muscular system being involved. The condition may be little more than a slight paresis, or may amount to a complete paralysis of the muscle.

ETIOLOGY.—These conditions may be due to functional derangement of the cortical centres, peripheral neuritis, or, what is more frequent, to some inflammatory condition of the mucosa in which the muscle becomes secondarily involved. The muscles most often affected are the thyreo-arytenoids (*Fig.* 121, C) (acute laryngitis and functional aphonia) and the posterior crico-arytenoids, sometimes the arytenoid (*Fig.* 121, D.) Functional paralysis of the thyreo-arytenoid muscles due to derangement of the cortical centres is always bilateral and has been considered already under FUNCTIONAL APHONIA (p. 205). Muscle paralysis due to laryngitis and gross lesions of the recurrent have also been dealt with. When muscles such as the crico-arytenoids or thyreo-arytenoids are involved, the laryngoscopic appearances are such as can readily be inferred from the known actions of these muscles. A glance at *Figs.* 89, 90, 91 will indicate them.

PROGNOSIS.—The prognosis is that of the causal condition. When due to laryngitis the paralysis soon passes off. When due to some peripheral intoxication such as is caused by diphtheria and influenza or plumbism, a longer period may ensue before the condition ultimately clears up.

TREATMENT.—If the paralysis occurs during laryngitis, the first essential is complete rest of the voice ; subsequent judicious and graduated exercise of the voice should take place. It will also be an advantage to employ external faradization, while strychnine internally is of service.

Paralysis of the Superior Laryngeal Nerve (Cricothyreoid Muscles).

Paralysis of the cricothyreoid muscles alone is a very rare condition. The nerve-supply is derived from the external laryngeal branch of the superior laryngeal nerve. According to Morell Mackenzie, paralysis may be caused by cold or by over-strain of the voice. Mygind has collected thirteen cases in the majority of which there was some bulbar lesion.

Symptoms. — These consist in a difficulty in producing the higher notes and in the voice becoming readily tired. On laryngoscopy, a wavy line of the cords can be detected (*Fig.* 122), and if the paralysis is unilateral the affected cord stands at a lower level than its fellow. Anæsthesia of the larynx is also present in most of these cases, and Morell Mackenzie has stated that if the finger be placed in

Fig. 122.—Paralysis of cricothyreoids.

the cricothyreoid space during phonation a lack of tension can be detected.

Treatment.—Treatment consists in massage of the neck, the application of faradic electricity and in hypodermic injections of strychnine.

VOCAL DISABILITIES OF SINGERS.

While various phonatory disturbances have already been considered in connection with the respective causal conditions, there remains a class of definite aberration of vocal function in which, at first at least, pathological changes are very slight or even absent. For want of a better definition they may be regarded as *maladies of the voice*. Their actual nature may pass unnoticed unless the sufferer is economically dependent upon the voice. In the case of a singer, where a higher degree of vocal precision is called for than in speech, the condition is a formidable menace to the livelihood of the sufferer and calls for immediate diagnosis and treatment before it becomes more firmly established and a cure more difficult.

Causation.—The voice may be imperilled at the outset, as the teacher may fail to recognize the exact category to which it belongs. For example, a voice may fit, as regards pitch and range alone, into one category, while its more important qualities of timbre, etc., would place it in another. The failure to recognize this may result in a mezzo-soprano being trained as a soprano, to the ruination of the voice. Another cause is over-training by reason of too long séances without short intermissions. Certain vowel sounds, useful for the purpose of training in one register, may be unfavourable for practice in another, each portion of the scale having its appropriate vowel sound for training purposes.

Failure to observe the hygiene of the voice may be a frequent cause of trouble—for example, singing when cold or immediately after a heavy

meal, excesses of diet or any other excess. In certain Continental State operas the female singers contract to rest the voice for three or four days in each month.

DIAGNOSIS.—Although general examination and laryngoscopy ought not to be neglected, the laryngologist will rely upon the symptomatology and the application of the vocal tests. The following are the more common faults encountered :—

Faults in the 'Medium'.—The trouble commences in two or three notes of the middle register of the voice. These tones become *détimbré*, and lose carrying power, and are accompanied by a sensation of loss of breath. The singer starts all right, but after a little practice this portion of the voice fails. The condition may be, and usually is, limited to the medium, but may eventually spread up and down the scale. Economically this is probably the most serious complaint ; as the speaking voice is also involved, it may entail a prolonged period of rest. While misuse may be causal, one must keep in mind a possible pulmonary condition. When the notes at fault are just *above* the interval between the middle and head register, a malady of the *medium* may be erroneously diagnosed. This, however, is much less serious and only requires attention to some errors of technique.

Loss of Range or Compass.—This occurs at either end of the vocal register. The fault is essentially one due to overstrain, especially in the higher register. The case requires carefully graduated exercises upon the medium register.

Changes in Timbre.—The condition may vary from a slight to a marked loss of timbre. The onset is usually insidious—sometimes intermittent after rest. It is occasionally associated with loss of staying power and weak range, and especially affects the upper notes. A frequent complaint is loss of *mezza voce*.

Where there is a definite inflammatory basis, the condition demands rest of the voice: fatigue should be avoided. Loss of resonance indicates nasal obstruction or some *damping* in the nasopharynx.

Loss of Solidity, Durability or Staying Power.—The voice soon becomes fatigued. There is tickling in, and dryness of, the throat. These persons have either used their voices excessively in speech, or have undergone a too intensive vocal training. This must be curtailed. A loss of staying power may show itself in the appearance of a tremolo and calls for drastic change in instruction.

Loss of Intensity, Strength or Carrying Power.—The singer finds that he is sensibly using more effort in singing and that he has to *nurse* especially the notes of the medium under risk of actual vocal discomfort or loss of timbre ; this condition, being largely due to impaired health requires general treatment. If the voice has been used for any length of time, the eventual recovery of health may come too late to save the voice from a degree of deterioration.

Loss of Flexibility.—Any loss of flexibility will be early noticed in a soprano, but much less so in voices of a lower pitch and timbre. The fault at first usually appears in the upper notes. Loss of flexibility in a previously good voice suggests the deposit of tubercle in the larynx.

CHAPTER XXVIII

TUMOURS AND INJURIES OF THE LARYNX.

INNOCENT TUMOURS.

Papillomata.—

PATHOLOGY.—These growths most commonly affect children. Nothing definite is known of their causation, but they appear to be infective in nature. They are similar in structure to papillomata in other regions, being composed of a vascular connective-tissue core covered by epithelium.

SYMPTOMS.—They most commonly betray their presence by considerable interference with the voice and respiration. Cough is a frequent symptom.

APPEARANCES.—Papillomata are usually seen attached to the false and true cords around the anterior third of the glottis, and are frequently multiple. They are freely movable, of a somewhat soft consistence, vary from a pale red to a drab colour, and have the typical cauliflower-like papillomatous appearance (*Plate XIII*, 3, p. 192).

DIAGNOSIS.—Papillomata may be mistaken for the somewhat similar formations of phthisis laryngea, but their anterior insertion, along with the absence of any clinical evidence of tubercle elsewhere, will serve to distinguish them from the latter variety. The absence of any marked alteration of the adjoining mucosa should also be noted and, where possible, a portion of the growth should be removed for histopathological examination.

PROGNOSIS.—Papillomata are chiefly dangerous in regard to the dyspnœa which they cause. They tend to recur after removal, but sometimes disappear spontaneously about puberty.

TREATMENT.—Where possible, growths should be extirpated via the natural passages, either with the help of indirect laryngoscopy or by the direct method (*see* Chapter XXX), the latter probably being preferable ; a general anæsthetic is employed. In cases of frequently recurring papillomata it may be necessary to perform tracheotomy, both for the purpose of enabling the child to breathe and in the hope of bringing about a spontaneous disappearance of the growths. Radium may be tried as a therapeutic method.

Fibromata or Fibromyxomata.—

ETIOLOGY.—These growths occur principally in adults, especially in the male sex. While nothing is known of their causation, they are frequently associated with some condition which causes chronic laryngitis.

PATHOLOGY.—These innocent tumours, or polypi as the pedunculated variety are called, are either a degeneraton or a new formation of the fibrous-tissue elements of the stratum proprium of the mucosa. When

pedunculated they somewhat resemble myxomata in appearance, and differ very little in structure from nasal or aural polypi. The sessile or pure fibromata show less tendency to the formation of myxomatous tissue and have a freer vascular supply.

SYMPTOMS.—The shape, size and position of the growths determine the symptoms they produce. The smaller growths, unless in the neighbourhood of the vocal cords, will at first seldom cause any alteration of the voice or respiration ; but if they are pedunculated there may be sudden temporary disappearance or alteration of the voice owing to the tumour being momentarily impacted between the vocal cords. A sessile growth on the vocal cords will, of course, produce continuous hoarseness or aphonia according to its size. The larger growths, unless encroaching on the glottis, seldom produce any dysphonia, at least until they attain a considerable size ; but if they are pedunculated, intermittent symptoms of acute dyspnœa may be met with. The larger growths may sometimes cause dysphagia. There is rarely pain associated with them.

APPEARANCES.—Fibromata are usually single and seldom of any size. They commonly affect one vocal cord and, when sessile, appear as a localized pink swelling of the region (*Plate XIII*, 4, p. 192). The pedunculated œdematous form, or fibromyxoma, is usually soft and paler in colour. and may appear attached to the under or upper surface of the cord. The tumour is seen to move upwards or downwards with respiration, at times disappearing out of sight between the vocal cords, or being nipped between them on phonation.

DIAGNOSIS.—The pedunculated variety does not often present any difficulty in diagnosis, but in the case of the sessile growths the question may arise as to their possible malignant nature. There may be noticed an absence of any marked alteration in the adjoining mucosa, and the free mobility of the vocal cord on the affected side. The rareness of cancer before the age of forty should also be kept in mind. In all cases, where possible, a portion of the growth should be removed for histopathological examination.

PROGNOSIS.—These growths are seldom dangerous to life, but considerable temporary or permanent damage to the voice may result from them. They only become dangerous when sufficiently large to cause dyspnœa, although severe cases of hæmorrhage are sometimes seen after their removal. Occasionally the growths may be torn off in a fit of coughing, or at other times shrink and disappear spontaneously. The pedunculated variety may be easily removed *per vias naturales*, and the voice may recover completely. There is little tendency to recurrence, provided the causal conditions receive some attention. It is doubtful whether malignant degeneration of these tumours ever occurs, but malignant growths, at an early period, may be mistaken for innocent tumours.

TREATMENT.—The growths should be extirpated where possible by way of the natural passages, but in some cases it may be necessary to resort to laryngotomy ; a single pedunculated growth is best removed via the mouth with the aid of either indirect or direct laryngoscopy.

Removal by Indirect Laryngoscopy.—These growths are now almost always removed by the direct method, under local or general anæsthesia.

The special technique and equipment necessary for this procedure are dealt with in the section on ENDOSCOPY.

Cysts.—

PATHOLOGY.—Cysts arise from the degeneration of the ordinary glandular tissue of the parts and are, therefore, more common in those regions where such tissue abounds, such as the anterior surface of the epiglottis and the aryteno-epiglottidean folds. Cysts usually contain glairy fluid. Branchial and dermoid cysts also occur in the larynx.

SYMPTOMS.—Cysts most commonly betray their presence by a degree of dysphagia ; less frequently they cause interference with the voice.

APPEARANCES.—Cystic tumours may appear of considerable size. They are more commonly seen on the lingual side of the epiglottis and sometimes appear to distend the ary-epiglottic folds. The size varies from a pea to a hazel-nut or even larger. Their surface is smooth, polished and transparent ; a few branching vessels may be seen running over it. Occasionally small cysts may be seen upon or just below the vocal cords.

DIAGNOSIS.—This presents no difficulty, as their appearance is quite typical.

PROGNOSIS.—The prognosis is not serious, as the tumours react readily to treatment and do not specially tend to recur.

TREATMENT consists in the free removal of the wall of the cyst. This may be done by means of a laryngeal punch by the indirect method or by direct laryngoscopy. Where the cyst is large, care should be taken that the fluid does not run into the larynx. In the case of larger cysts of congenital origin, external dissection should be carried out.

Adenoma, Lipoma and Angioma.—These forms are seldom seen. They are either a degeneration or a new formation of the ordinary tissue elements of the part.

MALIGNANT TUMOURS.

Malignant tumours of the larynx are usually divided for clinical purposes into 'intrinsic' and so-called 'extrinsic'. The term intrinsic should be applied only to growths of the vocal cords and the immediate surrounding neighbourhood. On the other hand, the term extrinsic is applied to growths which involve the upper orifice of the larynx, invading such parts as the epiglottis, the ary-epiglottic folds and even the ventricular bands. The extrinsic growths are in reality pharyngeal. The distinction is a necessary one, owing to the fact that the lymphatic supply of the region of the vocal cords is a somewhat closed system, so that there is little tendency at an early stage for these growths to spread to the surrounding parts ; thus a cure may be expected from the early removal of intrinsic growths while, on the other hand, the free lymphatic supply of the extrinsic or pharyngeal region admits of an early metastasis and a correspondingly less favourable prognosis. Some growths may be on the borderland between the two forms.

Intrinsic Cancer of the Larynx (Carcinoma).—Cancer of the larynx is more common after the fortieth year and in the male sex, but occasionally

occurs at an earlier period. While nothing definite is known as to the causal factors, the influence of heredity is of importance. Some of the cases are associated with a history of previous local irritation, caused either by chronic laryngitis or occasionally by some old syphilitic lesion. The intrinsic growths show microscopically the transitional-cell type of epithelium when originating in the ventricle but, when growing from the cords, they are of the typical squamous variety.

SYMPTOMS.—The symptoms are of less importance diagnostically than as a warning in drawing attention to the larynx. They vary according to the position and stage of the growth. Hoarseness lasting for more than a week calls for laryngoscopic examination, as persistent hoarseness without apparent cause is an early symptom, and in a male over forty years should suggest some serious laryngeal change. This may go on to complete aphonia. There is little or no pain at first ; but later, as the growth extends, pain, when present, is commonly unilateral and, on swallowing, is felt to radiate up to the ear of the same side and occasionally down the neck. Sometimes there is a tendency to glottic spasm and respiratory stridor. When the growth ulcerates, bloody sputum may appear. The general state is only affected later ; at this period the lymphatic glands may show involvement.

APPEARANCES.—It is only with the assistance of laryngoscopy that the diagnosis can be made. The growth may appear first as a papillary thickening of one vocal cord and, later, when ulceration has occurred, as a dirty-white slough (Plate XIII, 5, p. 192) ; occasionally it is seen as congestive thickening of one vocal cord. There is sometimes early fixation of the affected cord, but this must not be expected in most cases until later.

DIAGNOSIS.—One cannot too strongly impress the vital importance of an early diagnosis in this condition. Little assistance can be obtained from the symptoms or the general condition of the patient at an early stage, while the lymphatic enlargement which only occurs later may similarly be found in syphilitic and sometimes in tuberculous conditions. The sessile appearance of the growth, the early fixation of the vocal cord, and the slight alteration in the surrounding tissues are highly suggestive of cancer. The presence of either syphilis or tubercle will not, however, absolutely exclude the possibility of a cancerous affection ; but it is advisable to eliminate both these conditions if possible (see Chapter XXVI). The most certain method of diagnosis at an early stage is a histopathological examination, and this is best performed by means of direct laryngoscopy, when a portion of the growth may be removed and examined during the course of the operation. If its malignant nature be confirmed, the growth should be freely removed. The state of affairs must previously be fully explained to the patient and his permission received for the further operation.

PROGNOSIS.—This depends on an early diagnosis and on radical treatment. In a fair percentage of cases a cure may be expected. Where the growth has become extrinsic the prognosis is unfavourable. If the case is untreated, the viability varies from two to three years or even longer.

TREATMENT.—Early and free removal of the growth or its destruction by radium gives the best chance of cure. The removal should be as free as possible, and must include an area of surrounding healthy tissue (*see* THYREOTOMY, *below*). It may be necessary in some cases even to remove one half or the whole of the larynx. The risk of such an operation of course is great, but against this has to be considered the certainty of a painful termination if a radical operation is not performed. When an operation is refused, or the case is only seen late on, treatment which is palliative and is indicated under EXTRINSIC CANCER (p. 219) will be carried out.

Thyreotomy (Laryngofissure).—This operation is indicated principally in cases of strictly circumscribed intrinsic carcinoma of one vocal cord. It is occasionally employed in the removal of certain simple tumours of the larynx where the size, situation or vascularity is a contraindication to their removal by endoscopic methods. A firmly-impacted foreign body may necessitate its performance where the direct method offers special difficulties, as in the case of children.
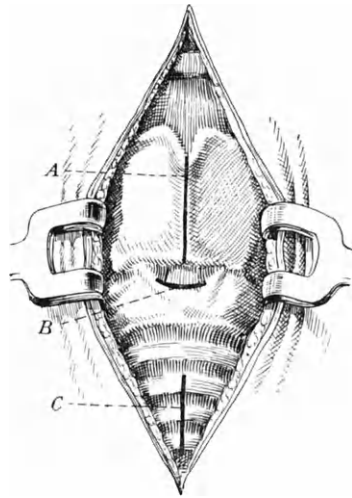
Fig. 123.—The incision here indicated exposes freely all tissues for the operation of thyreotomy with tracheotomy. (A) Line of division of thyreoid cartilage; (B) Position for entering the larynx in the operation known as laryngotomy or cricothyreotomy—a temporary expedient in certain emergencies; (C) Incision of the trachea through the 2nd, 3rd and 4th rings.
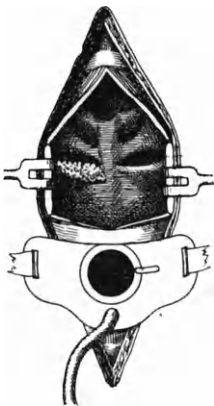
Fig. 124.—The operation of thyreotomy for the removal of an epithelioma of the right vocal cord. (N.B. The halves of the thyreoid cartilage are not so widely opened as is shown here.) Note the Trendelenburg cannula in the trachea.

The operation consists in the temporary splitting and separation of the two halves of the thyreoid cartilage exactly in the median plane (*Figs.* 123, 124). When the alæ of the thyreoid cartilage have been retracted, complete inspection of the interior of the larynx is afforded. A foreign body can be removed or an intrinsic growth dealt with. In the case of cancer of the vocal cord, packing the larynx with cocaine and adrenalin solution is a useful measure, as it assists accurate delimitation of the growth and also hæmostasis. If the growth is malignant and is confined to one vocal cord, the cord is separated from the cartilage by submucous dissection and the bulk of the cartilage removed. The separation of the vocal cord should allow for a wide margin of

healthy tissue around the growth and the portion containing the growth is removed with curved scissors. Bleeding is controlled, and before closing the larynx the field of operation should be perfectly dry. Tracheotomy is usually done as the first stage of the operation and is a safety measure which gives comfort and confidence to the patient. The tracheotomy tube is removed within twenty-four hours.

Radium.—Most encouraging results, up to date, have been obtained by the direct implantation of radium needles by the method originated by Ledoux (Brussels) and later elaborated by Finzi and Harmer—the so-called ' window operation '.

A reversed L-shaped incision is made over the thyreoid cartilage posteriorly from the centre of the hyoid, downwards then forwards. The infra-hyoid muscles are split longitudinally and the lateral aspect of the thyreoid cartilage exposed. Somewhat after the fashion of a submucous resection of the nasal septum, access is gained to the internal perichondrium (which must not be injured) by the removal of a square of cartilage large enough to permit the application of some five to ten platino-iridium needles of say 1 to 2 cm. in length and containing about 0·5 mgrm. of radium. The needles have attached silk threads soaked in 1–1000 flavine. The deeper tissues are now closed and immediately under the skin sutures are cached the silk threads knotted in a small bundle. A collodion dressing follows. At the end of four to eight days, according to the dosage, the knot is found just below the incision and gently withdrawn with the attached needles. The subsequent shrinkage and final (?) disappearance of the cancer may be observed laryngoscopically.

After-treatment.—The after-treatment of patients who have had laryngeal operations is of the utmost importance. The early return of the cough reflex should be encouraged and opiates withheld as far as possible. A steam tent may give relief for a few hours but should be discontinued at the earliest opportunity. Patients should be propped up in bed and moved frequently and, where the general condition will permit, should be out of bed at an early date—in forty-eight hours if possible. Where the operation has been undertaken for malignant disease, a course of deep X-ray therapy or irradiation by radium bomb of the affected area and the surrounding areas of lymph drainage will increase the chances of successful treatment.

Extrinsic Cancer of the Larynx.—The term extrinsic cancer of the larynx denotes those pharyngeal growths which encroach upon the upper orifice of the larynx and which are found on such parts as the epiglottis, the aryteno-epiglottidean folds and the ventricular bands. The most common variety is the squamous epithelioma with typical cell-nests.

SYMPTOMS.—These vary according to the position and stage of the growth. Symptoms in the early stage may be entirely wanting, the general condition being hardly affected ; but later, a degree of dysphagia and pain may be noticed. The pain at first is commonly unilateral, but sometimes, especially later, is bilateral. On swallowing, it is felt to radiate up to the ear, and occasionally down the neck. When the growths ulcerate, bloody sputum may appear, and marked fœtor of the

breath is present. The speech takes on a characteristic thick tone. Salivation is a distressing symptom. Later there is extreme cachexia.

APPEARANCES.—Extrinsic cancer appears as a red, granular ulcerated swelling, involving the epiglottis, the ary-epiglottic folds, or arytenoid region (*Plate XIII*, 6, p. 192); the edges appear thickened and, when palpable, have the characteristic epitheliomatous feeling. The floor of the ulcer is bleeding and fungating, but may be sloughy in appearance. When in the neighbourhood of the arytenoid region, there may be noted fixation of the corresponding crico-arytenoid joint, the cord appearing at rest in some atypical position. There is often considerable œdema of the surrounding tissue.

DIAGNOSIS.—At first, the symptoms may give so little assistance that an early diagnosis is the exception in this condition. The enlargement of the lymphatic glands, which often occurs before the local condition has become typical, may also be found in syphilitic and tuberculous conditions. One should endeavour to exclude these two latter conditions (*see* Chapter XXVI). The presence of either syphilis or tubercle, however, will not absolutely exclude the possibility of a coexistent cancerous affection. A portion of the growth should be removed for histopathological examination.

PROGNOSIS.—The prognosis depends, firstly, on whether there has been a timely diagnosis, and, secondly, on whether the general state admits of appropriate treatment. But even here, owing to the early involvement of the lymphatics and the rapid progress of the growth, the results are often disappointing. Where, however, the growth has spread by continuity and extensively involved the pharynx, a very much less hopeful prognosis can be made. At a later stage the extrinsic growths are not amenable to treatment, and metastatic involvement of the distant organs may have taken place. The condition is invariably fatal within a period of two or three years if untreated. A fatal termination is brought about by asphyxia or inanition. Occasionally a fatal hæmorrhage may ensue.

TREATMENT.—At present there are two main lines of treatment : one aims at complete surgical removal of the growth, while the other depends on radiation to destroy the malignant cells. Each method has its own advocates and successful results are reported by both lines of treatment. In early and localized disease radical operation undoubtedly gives as good chance of cure, but the operation is always mutilating as it involves extirpation of the larynx. With development of operative technique, and especially that of anæsthesia, the operative mortality has been greatly reduced, so that operation may be undertaken with a reasonable degree of confidence regarding its successful outcome. If disease has advanced to any extent, the operator must be prepared to undertake removal of portions of the pharynx, a procedure requiring great experience and a high degree of surgical skill.

Treatment by radiation has recently been gaining in popularity owing to the increasing success achieved by technical improvement and experience. The outstanding advantage of this method is the absence of mutilation and, in the successful case, the functional perfection of the result. On the other hand, a protracted period is required for complete

treatment—sometimes as much as three months or more. At times the discomfort occasioned by the reaction to treatment calls for considerable fortitude on the part of the patient. This problem of mental attitude is by no means the least of those encountered, as the majority of patients commence treatment with the feeling that their days are numbered.

Radiation treatment may be carried out by interstitial insertion of radium, by deep X-ray application or by radium bomb. Generally speaking, interstitial radium treatment is unsuited to the type of disease under discussion. Deep X-ray therapy has the greatest popularity at present, but recent developments in the use of the radium bomb show considerable promise. To discuss this treatment in detail is outside the scope of this work, and for further information the reader is advised to consult the various works and journals dealing with the subject. At the same time the chief difficulties become in the end the province of the laryngologist, and these may be referred to briefly. One of the most trying results of radiation treatment to the patient is the reaction which will set in two to three weeks after the commencement of treatment. This will take the form of reddening of the mucosa, accompanied by œdema and hypersecretion and dysphagia. If treatment is carried too far or is pushed too rapidly there may be urgent dyspnœa calling for tracheotomy, and the laryngologist may be required to decide as to the continuance or modification of treatment. Necrosis of laryngeal cartilage has occurred, and this may lead to stenosis of the larynx, which will present difficult problems of treatment.

The successful case, once the reaction is established, should show a homogeneous greyish membrane covering the part under treatment ; the growth then flattens and disappears under the membrane and when this clears away smooth, if swollen and reddened, mucous membrane is uncovered.

Palliative Treatment.—When extrinsic growths are found to be too advanced for hope of cure, treatment becomes entirely palliative. The free use of cocaine and anæsthetic powders may give some relief, but the most successful treatment is the administration of small doses of X rays. These need not be carried to the point of producing uncomfortable reaction but will usually prevent rapid progress of the growth and may even cause its retrogression for a time. In more advanced cases, gastrostomy and tracheotomy may be required. Various sera have been suggested as influencing the progress of the disease but so far none has justified its recommendation.

Sarcomata of the laryngopharynx are very uncommon. These growths may be primary but are probably more frequently secondary, and many varieties of sarcoma are recorded following or accompanying disease in other parts of the body. Before ulceration they are smooth and slightly yellowish-red, but when ulcerated they are hardly distinguishable clinically from epitheliomata. The lymphatic glands are certainly less frequently affected and their growth is slower, so that they are not so soon fatal.

TREATMENT is similar to that of epithelioma, with the exception that radiation treatment should be the first line of defence.

TRACHEOTOMY.

The anatomical data necessary are few, as only the simple anterior relations of the trachea need be considered. The trachea lies exactly in the median line of the neck. Superficial and easily palpable at its commencement below the cricoid cartilage, the trachea passes downwards and backwards, so that in the lowest part of the neck it can be felt, if at all, only by deep palpation. The skin, subcutaneous tissue and deep fascia which cover it at the level of the first ring are separated from the second, third and fourth rings by the isthmus of the thyreoid gland. At this level, superficially, are encountered branches of the anterior jugular veins, and deeper—often indistinguishable from the isthmus—a profuse mass of anastomosing superior and inferior thyreoid veins. The veins are not in actual contact with the trachea, as they are supported by a layer of the deep fascia (pretracheal), which permits of their being bodily drawn aside together with the isthmus of the thyreoid. There are no arteries of importance, or muscles, in the median line in front of the trachea.

Indications.—Tracheotomy is indicated for the relief of temporary or progressive mechanical obstruction to the passage of air or excretions through the larynx or upper trachea, or as a precautionary measure wherever asphyxia from such a cause is anticipated.

Occasionally tracheotomy is performed for the purpose of gaining safety where operation on the larynx is contemplated, such as the removal of multiple papillomata in children. In adults, affections of the larynx occasionally calling for tracheotomy are tubercle, syphilis, cancer, œdema glottidis and laryngeal spasm ; and in the trachea, tumours, stenosis, fractures and wounds. Affections of the neighbouring organs may necessitate its performance, foreign bodies and cancer of the œsophagus, enlargement of the thyreoid gland, and extensive tumours of the pharynx and base of the tongue. It is more rarely indicated for serious syncope during anæsthesia, and it is occasionally a preliminary procedure in the direct local treatment of certain lower tracheal conditions (foreign bodies). In children the following indications are met with : foreign bodies in the larynx, retropharyngeal abscess and stridulous laryngitis. Tracheotomy is less frequently required in cases of diphtheria since the introduction of Behring's serum and intubation.

Instruments.—These should be as few as possible, namely, one or more tracheotomy tubes of suitable size—the outer tube mounted with tapes—a bistoury, artery forceps, two blunt hooks, dissecting forceps, a grooved director, false-membrane forceps, feathers, gauze pads and swabs.

Preparation of the Patient.—In the case of a child, the body and arms should be wrapped in a sheet, employing no pins or other fastenings ; the operating table should be narrow and somewhat high ; a good light is essential. At least two assistants are required : one to hold the head in the median line while the other controls the legs and arms.

Anæsthesia.—In most cases a local anæsthetic will be sufficient unless resistance is to be anticipated, as in the case of a robust individual or a

young child. The presence of extreme dyspnœa will in all cases contra-indicate the use of a general anæsthetic. If time permits, the usual preparation of the skin is desirable, but otherwise it may be swabbed with iodine in spirit.

For local anæsthesia a sufficient quantity of $\frac{1}{2}$ or 1 per cent solution of novocain with a drop or two of adrenalin should be injected under the skin so as to control with an ample margin the area of the proposed incision. A cushion is then placed under the shoulders and the assistants control the patient as above noted.

The Operation.—The surgeon stands on the right of the patient ; with the left hand the anatomical bearings are taken ; the index finger is placed upon the cricoid cartilage, while the other fingers and thumb at each side grasp and fix the larynx. The index finger should not leave the cricoid until the trachea is exposed.

First Stage.—With the bistoury in the right hand an incision at least two inches in length is made *exactly in the middle line*, from the cricoid to the episternal notch, cutting through skin and superficial structures ; successive strokes of the bistoury cut the deeper fascia, which is retracted by the weight of the artery forceps which are holding any bleeding points, always keeping the incision the same depth through-out the length of the wound. A slight transverse cut of the pretracheal fascia just below the cricoid, through which the grooved director is inserted, enables one rapidly to expose the upper part of the trachea. A blunt hook retracts the isthmus of the thyreoid gland downwards, or it is cut and ligatured, and the first three or four rings come into view. After a careful hæmostasis—

The Second Stage is commenced by sharply puncturing the trachea at the fourth ring, exactly in the middle line, and deliberately cutting upwards the third and second rings (*Fig.* 123, C). If time permits, before opening the trachea a few drops of 5 per cent cocaine may be injected into the trachea by a hypodermic syringe and needle. This minimizes the spasmodic coughing occasioned by the opening of the trachea. The sound of the cutting and the subse-quent tracheal breathing are most characteristic. The index finger of the left hand temporarily closes the trachea, and the bistoury is laid aside.

Third Stage.—Before inserting the cannula an oval opening may be made in the trachea by removing a small portion from each cut edge with a ring punch forceps. This facilitates introduction of the tracheal tube, makes subsequent nursing simpler, and prevents necrosis of the tracheal cartilage. The outer tube of the cannula is held in the right hand and presented horizontally from the left or far side of the neck, the convexity forwards. The tube should then enter easily, but if not the trachea dilator is introduced closed and allowed to open. In the absence of a dilator the handle of the bistoury may be used. The point of the tube being now in the trachea, the rest of it is rotated into the middle line, and the introduction is completed. The tapes are then fastened round the neck. The inner tube may now be inserted if every-thing is in order.

Special Difficulties and Accidents.—Hæmorrhage, if slight, usually stops as soon as the cannula is in position ; if not, a larger cannula should be inserted ; this, with the application of a little pressure, is generally effective. Sometimes after the cannula is apparently in position the patient does not breathe through it ; the cannula may not be in the trachea but in the surrounding fascia. It should then be removed and a fresh attempt made. If the tube is in the trachea, the obstruction is possibly due to a clot of blood or a piece of diphtheritic false membrane, which may be removed by the forceps specially provided for this purpose. In the absence of any of these conditions the stimulation of the tracheal mucosa with a feather may be sufficient to restart the breathing, but, failing this, artificial respiration should be resorted to.

After-care.—A warm bed will be prepared and a bronchitis kettle provided if the ward or house is cold. Moist gauze pads over the tube are essential. The inner tube should be changed every two or three hours. The outer tube will be changed and the wound dressed after twenty-four hours ; this is repeated daily.

The tracheotomy tube should be dispensed with as soon as possible ; the wound soon granulates and closes. In some cases, the immediate indication for the operation having passed, the wound may be closed by suture. In cases of serious progressive disease of the larynx the tube will be permanently employed.

Post-operative Complications.—If an appreciable amount of blood should gain entrance to the trachea, bronchopneumonia may be set up. Emphysema of the neck is usually due to a too short superficial incision, but it soon passes off. Any inflammatory reaction of the wound should receive appropriate treatment.

StClair Thomson regards a badly performed (too high) tracheotomy as by far the commonest cause of stenosis of the larynx and, after forty years' experience, strongly recommends a permanent tracheostomy for the alleviation of this complication and also for stenosis in other conditions such as traumatism, bilateral laryngeal paralysis, tuberculosis, lupus and syphilis.

Where a tracheotomy tube has been worn for a long period great difficulty may be experienced in training a child to breathe without the tube, although the necessity for its use may have long since disappeared. The removal of the tube in these cases must be preceded by gradual reduction of the air intake through the tube. This is most easily effected by corking an increasing area of the tube mouth until the patient can sleep comfortably with the tube corked completely. The actual closure of the opening is most easily effected by the formation of a skin flap which is swung over the opening in the trachea and stitched into position, epithelial surface inwards. The deficiency in epithelium is made good by mobilizing the skin and stretching it over the raw area. The flap may be taken from the side of the neck or from the chest. Any attempt to mobilize the edges of the tracheal opening and stitch them together will almost certainly fail owing to the tension and lack of vitality in the skin surrounding the opening.

INJURIES OF THE LARYNX.

Injury to the larynx may be caused by a blow or kick, or more commonly occurs owing to compression in throttling. The injury may consist of bruising or fracture of the cartilaginous framework, which again may be accompanied by laceration of the mucosa. In bruising of the larynx there may be pain and tenderness externally, with swelling which is usually related to some cartilage. Laryngoscopy may reveal submucous hæmorrhage and possibly œdema, which may seriously threaten to obstruct the larynx. Where there is fracture the prognosis is less good owing to the frequency with which there is laceration of the mucous membrane. In these cases hæmorrhage and emphysema may quickly cause a fatal termination.

TREATMENT.—In cases of bruising, sedatives, ice-bags to the neck and rest of the voice are the best measures. Where there is more serious damage, in addition to the remedies just detailed, tracheotomy may be urgently required, while to control hæmorrhage and deal with lacerations laryngo-fissure is in some cases the wisest course. Following severe injury there is almost always alteration of voice, and if there is serious laceration permanent tracheotomy may be required.

CHAPTER XXIX

VARIOUS CONDITIONS OF THE LARYNX AND AFFECTIONS OF THE LINGUAL TONSIL.

CONGENITAL MEMBRANES OF THE LARYNX.

CONGENITAL membranes are rarely met with ; they are for the most part situated at the anterior commissure, but may be subglottic. When they stretch between the cords and are of any size, they may cause interference with respiration and phonation.

TREATMENT should be undertaken only when symptoms are produced. In such cases, removal should be attempted by the endolaryngeal method ; it may be necessary subsequently to use bougies to prevent adhesions forming.

HYPERTROPHY OF THE LINGUAL TONSIL.

The lingual tonsil is a mass of lymphoid tissue, normally found on the dorsum of the tongue, between the vallate papillæ in front and the epiglottis behind. Hypertrophy of the lingual tonsil is not a common affection and, unlike hypertrophy of the faucial tonsils, is usually met with in adults and occurs more frequently in women than in men.

SYMPTOMS.—When sufficiently enlarged to touch the epiglottis, it may cause the sensation of a foreign body in the throat ; but cough and even pain may be produced, and the hypertrophy, when extreme, may give rise to interference with deglutition.

APPEARANCES.—In marked cases the back of the tongue and the valleculæ are seen to be covered by an irregularly shaped mass, presenting a central furrow and a nodular surface, with which the lingual aspect of the epiglottis is in contact. In less pronounced cases the tip of the epiglottis does not touch the mass when the tongue is protruded.

TREATMENT.—In slight cases it may be sufficient to paint the back of the tongue with Mandl's solution (see Appendix) ; but if this does not relieve the symptoms, the mass may be reduced by the galvanocautery, or the greater part of it may be removed by the lingual tonsillotome. Local anæsthesia should first be induced by means of a local application of a 10 per cent solution of cocaine or injection of 1 per cent solution of novocain. In many cases general treatment is required, as these patients are frequently anæmic or neurotic.

The lingual tonsil may participate in acute or subacute inflammations of the pharynx.

A variety of tumours have also been met with at the base of the tongue, such as polypi, cysts, papillomata, fibromata, adenomata, carcinomata.

15

BOULAY'S METHOD OF INJECTING THE SUPERIOR LARYNGEAL NERVE FOR THE PRODUCTION OF TEMPORARY OR PROLONGED ANÆSTHESIA OF THE LARYNX.

The larynx is caused to project on the side to be injected by pressing on the opposite side with the thumb. With the index finger one palpates the thyreo-hyoid space, running the nail from behind forwards until the painful point corresponding to the nerve is determined (*Fig.* 101, p. 163). This point is found at about the middle of the line joining the great cornu of the hyoid bone and the postero-superior angle of the thyreoid cartilage. The position may be marked with tincture of iodine. The needle of a syringe containing a 2 per cent solution of novocain with adrenalin is then pressed in perpendicularly for a distance of about 1 cm. When the needle passes through the muscles a distinct sensation of resistance is encountered, after which the needle is felt entering the free space which corresponds to the lax connective tissue around the nerve ; on touching this a distinct sensation of pain is felt in the ear, which becomes momentarily increased as the injection begins, but shortly passes off, as the anæsthesia of the larynx commences to be established. If a more lasting effect is desired, the barrel of the syringe may be dismounted and filled with 1 c.c. of 83 per cent alcohol. The resultant anæsthesia may last a varying period, from a few days to some weeks. If the condition is bilateral, both sides should be similarly treated.

Section V.

PERORAL ENDOSCOPY.

G. EWART MARTIN.

CHAPTER XXX.

DIRECT LARYNGOSCOPY, TRACHEOSCOPY, BRONCHOSCOPY, AND ŒSOPHAGOSCOPY.

THE general term 'peroral endoscopy' includes all those methods by which a direct inspection may be made of the larynx, trachea, lower air-passages and œsophagus. (*See Fig.* 129, p. 232.)

A varied armamentarium (*Fig.* 125) is required to pull apart the
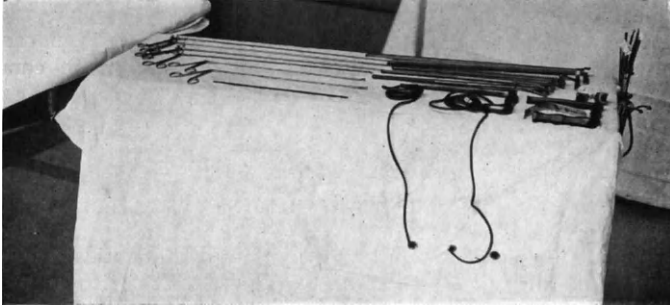
Fig. 125.—Outlay of instruments for endoscopy, showing battery connections and pump connections.

anatomical obstructions in the direct line of vision, but the examination is mainly made by means of a rigid tube passed through the mouth down to the larynx, trachea and bronchi, or into the œsophagus.

The illumination of the field of vision is the initial difficulty. Two main types of illumination are now employed :—

1. Proximal lighting, obtained by a Kirstein or a Guisez headlamp worn on the forehead, which projects a thin beam of light along which the eye can look down the tube ; or, by the Brünings' type of electro-scope attached to the handle of the apparatus, by which light is reflected down the tube from a small perforated mirror through which the eye can look.

2. Distal lighting is the type employed by Chevalier Jackson in his various tubes. An auxiliary channel on the under surface of the tube contains the light-carrier ; the small electric bulb lies in a recess in its distal end.

Illumination, either distal or proximal, is, after all, largely a matter of personal choice and does not call for discussion here.

It is not proposed in this chapter to enter into a full description of peroral endoscopy. The armamentarium required for such examination is necessarily large and its employment is practically impossible by the general practitioner. It entails constant practice which can only be obtained in special hospitals, or in a special department of a general hospital. In the hands of the specialist, however, peroral endoscopy has a wide and important field. It gives a valuable means of treating affections of the œsophagus and bronchi.

Œsophagoscopy gives the only means of carrying out an examination of the lower pharynx, œsophagus and upper end of the stomach in the living subject. Bronchoscopy bears a somewhat similar relation in the examination of the chest as cystoscopy does in the examination of the kidney and bladder. With a bronchoscope the lung can be inspected from inside the chest and it is possible to bring under direct vision the trachea and smaller bronchi with the exception of the right eparterial bronchus, although its opening into the main bronchus can be fully inspected. Through a bronchoscope lipiodol can be injected, or any similar opaque medium for the purpose of outlining any part of the lung for radiological examination and through the bronchoscope affections of the chest can be treated. Although the actual practice of endoscopy is beyond the scope of general practitioners the pathological conditions calling for its use should be known to them.

ANATOMY.

The **Pharynx and Larynx** have been previously described (Chapters XIV and XXII).

The **Trachea** begins at the lower margin of the cricoid cartilage, opposite the inferior border of the 6th cervical vertebra ; it ends opposite the 5th dorsal vertebra by dividing into the two main bronchi. Occupying the median plane, the trachea deviates slightly to the right at its lower end. The cartilaginous rings are deficient posteriorly, where the cartilage is replaced by the musculus trachealis, composed of transverse fibres supplied by the recurrent laryngeal nerves. Seen through the bronchoscope, the trachea is flattened on its posterior wall, the mucosa is moist and glistening, whitish in ridges corresponding to the cartilaginous rings and darker in colour between them.

In the adult male, the distance from the upper molar teeth to the glottis is about 11 cm. ; from the glottis to the bifurcation of the trachea 12 cm. These measurements necessarily differ in a child about the age of ten years. In this case the distance from the molar teeth to the glottis is roughly 7 cm., and 6 cm. separate the glottis from the bifurcation of the trachea.

The trachea, just below its entrance into the thorax, deviates slightly to the right to allow room for the aorta ; hence pulsation from the aorta is transmitted to it. The anterior landmark of its bifurcation is roughly the second right chondrosternal articulation. The diameter of the trachea is from 15 to 22 mm.
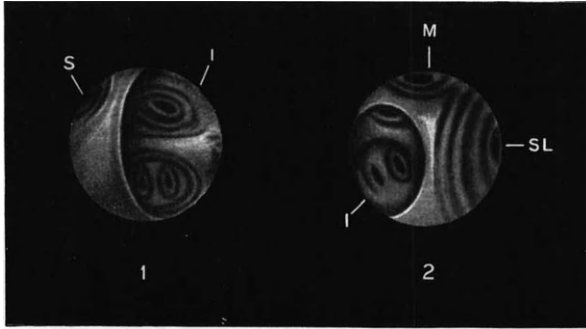
Fig. 126.—Bronchoscopic views of (1) Left bronchus, (2) Right bronchus. (S) Superior lobe bronchus; (SL) Superior lobe bronchus; (M) Middle lobe bronchus; (I) Inferior lobe bronchi.

The right main bronchus appears to be almost a continuation of the trachea ; it is larger than the left main bronchus and its diameter is very little less than that of the trachea. Thus foreign bodies are far more liable to enter the right than the left main bronchus. The bronchoscope also passes more easily into the former. The right main bronchus gives off a superior lobe bronchus called the right epar- terial, as it passes above the pulmonary artery ; farther on, it gives off a middle bronchus, and continues as the inferior bronchus. The right main bronchus makes an angle of about 25° with the vertical and its length unbranched is about 2·5 cm. *The*
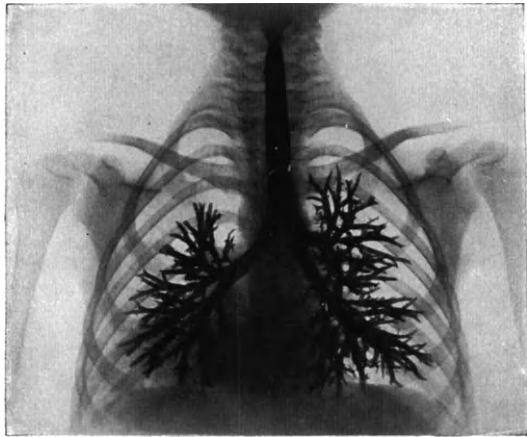
Fig. 127.—Radiograph of tracheo-bronchial tree, viewed from behind.

left main bronchus is longer, being about 5 cm., and makes an angle of 75° with the vertical (*Fig.* 127). Thus, with a knowledge of landmarks and lengths, the trachea and bronchi can be mapped out on a radiograph. and the position of any foreign body thus revealed may be determined

with moderate accuracy.   The lumen of the individual bronchi diminishes only slightly as the main bronchi bifurcate, so that the bronchoscope can be passed through both main bronchi and into the inferior branches. The spur between the two bronchi at the bifurcation of the trachea is called the carina.   This is seen in the bronchoscope as a white shining ridge, with the mouths of the bronchi on each side (*Fig.* 126).   By means of insufflation of bismuth and an X-ray photograph, the bronchial tree may be seen *in situ*, and the possibility of a blocked bronchus detected (*Fig.* 127).

The Œsophagus is a very easily distensible tube, with relatively thin walls ; it commences immediately below the level of the cricoid cartilage and terminates at the opening into the stomach below the diaphragm. Its measurements are given in the following table :—

	From Incisor Teeth to Opening of Œsophagus	From Opening of Œsophagus to the Level of Bifurcation of Trachea	From the Level of Bifurcation of Trachea to Cardiac End of Œsophagus
Adult male	15 cm.	11 cm.	14 cm.
Child of 7 years	10 cm.	8 cm.	9 cm.
Infant	7 cm.	6 cm.	5 cm.

Thus the whole length of the œsophagus in the adult is 25 cm., while from the teeth to the cardia the average distance is 40 cm.

The œsophagus receives its nerve-supply from the vagus and sympathetic.   The lower part of the inferior constrictor of the pharynx is supplied by the pharyngeal plexus.   The cervical œsophagus receives some branches from the recurrent laryngeal nerve, and in the chest branches are received from the vagi which accompany the œsophagus in its passage downwards, the left vagus lying on the anterior surface and the right vagus on the posterior surface of the œsophagus.

The œsophagus enters the thorax in a direction downwards, backwards and slightly to the left, until it passes behind the left bronchus, when it turns forwards and to the left as far as the opening through the diaphragm.

The diameter of the œsophagus shows great variations and at least four constrictions :   (1) At its mouth, the cricopharyngeal constriction, opposite the 6th cervical vertebra ;   (2) At the crossing of the aorta, opposite the 4th dorsal vertebra ;   (3) At the bifurcation of the trachea, opposite the 5th dorsal vertebra ;   (4) As it passes through the diaphragm, opposite the 10th dorsal vertebra.

These constrictions are easily distensible, the cricopharyngeal being less so than the others.   The cricopharyngeal constriction is probably the narrowest part of the œsophagus, being flattened from before backwards ; it is immediately below this region at the entrance of the bony thorax that coins usually lodge and appear in surface view in an antero-posterior radiogram just above the episternal notch.   As in this region the trachea is flattened from side to side, only the edge of a coin lodging in the trachea will be visible in an antero-posterior radiograph (cf. *Figs.* 134, 135, p. 250).

In carrying out peroral endoscopy asepsis must be carefully practised as in any surgical operation, especially so in the examination of the chest where the lining of the bronchi can be easily infected. The operator himself should be thoroughly protected against the patient coughing into his face by wearing an efficient mask and also goggles prepared with some anti-dimming substance. It is possible to carry out the examination of the larynx and upper end of the œsophagus through suitable tubes with the patient in the sitting position, but this position is more uncomfortable for the patient and even more so for the operator ; nor does it allow of an efficient view. The recumbent position on an ordinary operating table is the only satisfactory one for all cases of œsophagoscopy and bronchoscopy.

Endoscopy does not necessarily require a general anæsthetic save in exceptional circumstances as in the case of nervous children. General anæsthesia gives an unnecessarily added risk to the examination. In very nervous adults the use of luminal or nembutal or some such similar drug before the operation is all that is necessary along with a local anæsthetic. The local anæsthesia is obtained by spraying the throat with $\frac{1}{4}$ drachm of 10 per cent cocaine. For bronchoscopy a further addition of 20 per cent cocaine applied in pledgets of gauze held in special curved forceps in the pyriform sinuses with the object of blocking the superior laryngeal nerve allows the bronchoscope to pass between the cords without any spasm of coughing (*Fig.* 128). In young children no anæsthetic is required ; the child is held in position on the table by two assistants and very little discomfort is experienced.

Fig. 128.—Preparation of patient: cocainizing the pyriform sinuses with pledgets of gauze dipped in 20 per cent cocaine held in curved forceps.

A preliminary hypodermic of atropine is necessary before endoscopy. Morphia and heroin can be given before œsophagoscopy but it is better not to give it before bronchoscopy in diseases of the lung where there is excess of secretion, as it tends to diminish the cough reflex.

DIRECT EXAMINATION OF THE AIR-PASSAGES.

The Larynx : Laryngoscopy (*Fig.* 129).—A detailed description of the various methods of direct laryngoscopy, whether by the use of a simple tube spatula or by the more complicated instruments of the type of Hasslinger's directoscope is impossible here. It is proposed, however, to give a brief description of the use of the distally illuminated laryngoscope and œsophagoscope as suggested by Chevalier Jackson.

The indications for direct laryngoscopy can only be briefly mentioned here.

a. In children, where the indirect examination of the larynx is almost always impossible, direct examination is the only alternative.

b. In cases of laryngeal affections in the adult, where the indirect examination cannot be carried out, the patient should always be examined by the direct method with a view to diagnosis and treatment.

c. The removal of a simple tumour, or a foreign body, from the larynx can more readily be carried out by the direct than by the indirect method ; but it should be borne in mind that the laryngeal mirror can never be supplanted, and should be used, where possible, in preliminary examination.

There are practically no contra-indications to direct laryngoscopy.

OPERATION. — *Preparation*. — The patient, unless in an emergency, is prepared as for any surgical operation. Even if no anæsthetic is to be used, there should be fasting for at least four or five hours. If the operation is to take place in the morning it is better that no solid food should be given after six the previous evening, apart from a cup of weak tea without milk early on the morning of the operation. In every case there should be a preliminary examination of the larynx by the indirect method.

A hypodermic injection of $\frac{1}{200}$ gr. of atropine is given, and in some cases $\frac{1}{6}$ to $\frac{1}{4}$ gr. of morphia. Immediately before the operation the throat is sprayed with 15 min. of 10 per cent cocaine using an ordinary De Vilbiss spray. To further anæsthetize the larynx curved forceps holding pledgets of gauze dipped in 20 per cent cocaine are held for one minute or so in the pyriform sinuses. The head of the patient is covered with a sterile gauze bag with a little hole cut out for the mouth. Sterile towels are put over the end of the table, and the patient can then be handled more easily than if he were pinned down with towels.
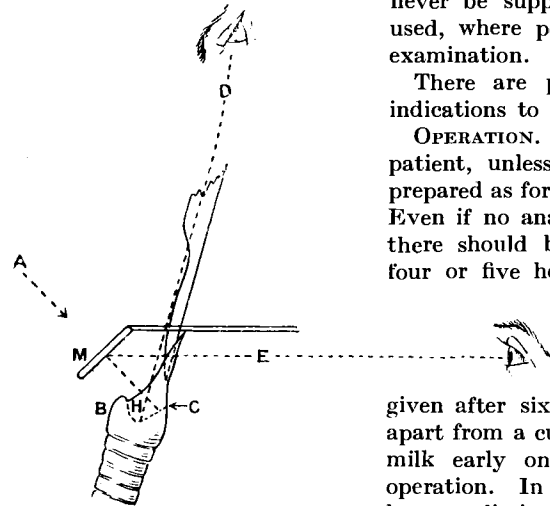
Fig. 129.—Schema illustrating the difference between the views obtained by direct and by indirect laryngoscopy. The observer's visual axis at E, looking into the mirror M, gives an image as if he were looking from a point at the back of the patient's head, A. Looking thus, the image of a growth on the cord at C is seen just over the top of the arytenoid eminence, to which it seems very close, because almost in line. This schema also shows how the anterior surface of the posterior wall at H is in the line of vision by direct laryngoscopy D, and more or less hidden in some cases during indirect examination, by an apparent forward overhang of the border of the arytenoid eminence and the ary-epiglottic fold.

Position.—The dorsal recumbent is the most satisfactory position for peroral endoscopy (*Plate XIV*, A and B, p. 234). The patient is readily controlled, the head is freely movable, and a true direct view is obtainable. The sitting position is difficult for the operator, more difficult still for the assistant and rather terrifying for the patient.

The holding of the patient is almost the most important part of the

operation.   The aim of the assistant is to hold the head in such a position that the cavity of the mouth and the pharynx are in a straight line with the trachea and œsophagus.   The patient should be encouraged to hold himself as loosely as possible, the assistant doing all the movement that is necessary.   A second assistant holds the shoulders of the patient firmly on the table so as to prevent any elevation of the chest.

In direct laryngoscopy the head is held by the first assistant sitting on the right of the patient ; his right hand is under the neck with the palm of the hand on the patient's left cheek to prevent any rotation of the head, with the middle finger holding a bite-block in the patient's mouth. The left hand is under the occiput.   To gain the initial position the head and neck are flexed upon the chest and the head then extended on the occipito-atloid joint.

In bronchoscopy and œsophagoscopy the first assistant has to follow every movement of the endoscopist, so that the different curves of the trachea and bronchus and the œsophagus are brought into a straight line.

The laryngoscope is held in the left hand at the junction of the horizontal and vertical bars so as to prevent the tendency to use it as a lever.   The right hand holds back the patient's upper lip.   The tube spatula is then introduced and passed along the right side of the tongue, the point being directed towards the middle line as it approaches the posterior third of the tongue.   The epiglottis then projects into the field of vision.   It is picked up with the spatula point of the laryngoscope.   A further advance of the laryngoscope exposes the larynx, suspending as it were the chin, tongue and epiglottis on the spatula, care being taken not to use the tube as a lever and the upper teeth as a fulcrum.   The patient breathes deeply and easily.   The larynx comes readily into view, widely open with the cords revealed. The anterior commissure can be inspected more readily if the assistant presses the thyreoid cartilage backwards and upwards, increasing slightly at the same time the angle at which the head is tilted backwards.

Probably the most common mistake made in commencing direct examination of the larynx is to pass the tube spatula too far into the mouth, failing to identify the epiglottis in the passage downwards.   The tip of the laryngoscope then comes to lie behind the arytenoids, and in attempting the suspension movement the larynx is pulled forwards and only the hypopharynx is revealed.   Care must also be taken to prevent the patient's head rotating, as the ary-epiglottic folds might then be mistaken for the epiglottis and the larynx again swung forwards.

In very muscular people with a certain amount of spasm it is sometimes difficult to recognize landmarks.   In such cases, the less extension applied to the head, the less muscular tension there is of the muscles of the neck and, consequently, the tube can be moved about more readily.

In children the epiglottis is usually relatively much longer and very often involuted.   Thus it is more difficult to pick up with the tip of the spatula ; the epiglottis slips off much more readily if the spatula is not quickly advanced.   Only with constant practice and knowledge of landmarks can this difficulty be overcome.

The Trachea and Bronchi: Tracheoscopy and Bronchoscopy.—The direct examination of the trachea and bronchi is necessarily a further step of direct laryngoscopy.

OPERATION.—The preparation of the patient is the same as for laryngoscopy (*Plate XIV*, C and D). The larynx is exposed with the illuminated laryngoscope held in the left hand. The illuminated broncho-scope is then handed to the operator by the instrument clerk or sister, so that its handle rests lightly in the right hand between the two fingers and thumb and pointing towards the right. It is then passed through the tube spatula down to the larynx; the operator looks down the bronchoscope instead of the laryngoscope. The tip of the bronchoscope is insinuated between the vocal cords with the bevelled portion of the tube pushed against the left cord. The bronchoscope will then slip readily through the glottic chink. No force of any kind must be used, the bronchoscope being held only between the fingers and never grasped firmly in the hand. When the bronchoscope has passed down the trachea a short way, the slide of the tube spatula is removed and the laryngoscope taken out of the mouth. The examination of the trachea and bronchi is then carried out with the bronchoscope, care being taken to see that the axis of the trachea and bronchoscope coincides, never using the tube as a lever.

When the bronchoscope is inserted through the glottic chink the patient may have a severe attack of coughing. This is partly reflex and partly due to nervousness on the part of the patient. The bronchus can be sprayed with 5 per cent cocaine through the bronchoscope to lessen any irritation and consequent coughing. It is always best to warn the patient that he will feel a little difference in breathing through the tube, and to assure him that there is no danger of choking, but that in reality he is getting too much air.

The beginner, if he is flustered, sometimes misses the glottic chink and passes the bronchoscope behind the arytenoids into the œsophagus. There will be no rush of air through the tube, and the collapsed walls of the œsophagus should be readily detected.

In the case of a lung abscess or of bronchiectasis, when aspiration or lavage of the cavities is attempted, an aspirating bronchoscope is used attached to a suction apparatus. In such a case the operator must remember that, during the initial fit of coughing, fluid may be projected from the tube, blurring the operator's field of vision and choking and alarming the patient. In such cases it is best to pass the tube very slowly so as to give the suction apparatus full play.

Tracheoscopy and bronchoscopy should be carried out in the following cases :—

a. Where the history, symptoms and X-rays indicate the presence of a foreign body in the trachea or bronchus.

b. Where there are a history and physical signs of a 'non-opaque' foreign body in the bronchus which cannot be detected by the X-ray.

c. Chevalier Jackson considers that cases of bronchiectasis should be bronchoscoped to exclude the possibility of a foreign body, and also for local treatment.

d. Cases which show all the physical signs of tuberculosis, without the tubercle bacillus being detected, particularly where the apices are not affected, should be X-rayed and bronchoscoped for foreign bodies.

e. Cases of dyspnœa due to non-obvious diseases of the lung.

f. Cases of recurrent nerve paralysis of obscure origin.

g. Tracheal or bronchial stenosis.

h. In cases of lung abscess and bronchiectasis with a view to aspiration and lavage.

i. Cases of bleeding without obvious lesion.

There are practically no contra-indications to bronchoscopy, but only in very urgent circumstances should the removal of a foreign body through the bronchoscope be attempted in cases of aneurysm, pulmonary tuberculosis, mitral incompetence and advanced arteriosclerosis.

DISEASES OF THE TRACHEA, BRONCHI AND LUNGS.

No detailed account of the diseases of the trachea and bronchi will be given, but merely a brief account of the symptoms appertaining to the common affections in this region, so as to assist the reader in recognizing when direct examination is necessary.

Inflammations of the trachea are discussed fully in medical treatises ; laryngeal and tracheal syphilis and tuberculosis—the symptoms of which were dealt with in Chapter XXVI—are more readily treated by general methods although, in particular cases, they call for local treatment, e.g., removal of small portions of diseased tissue, cauterization, radium applications, which can be carried out more easily by direct endoscopy.

Benign and malignant growths of the trachea and intrinsic stenosis require intratracheal treatment. The most common causes of intrinsic stenosis of the trachea are : (1) Adhesions or contractions following traumatism due to direct or indirect injury or wounding, or from operative interference, such as tracheotomy and intubation. (2) Foreign bodies. (3) New growths. (4) The granulomata—syphilis and tuberculosis. (5) Extension downwards from the larynx of inflammatory œdema, including the effects following upon the respiration of poison gases.

The extrinsic type of stricture is usually due in the cervical region to the pressure of an enlarged thyreoid, or of glands, chiefly malignant ; in the thorax, the pressure of an aneurysm or of a mediastinal growth may cause stenosis.

The symptoms depend on the degree of the narrowing. In a slight case there is very little change except the slightly noisy respiration and dyspnœa on exertion, increased with succeeding attacks of 'cold'. In an extreme case, the patient walks with the head held forward in order to free the air-passages, and he is always fighting for breath.

Stenosis of the trachea due to cicatricial changes can be treated by frequent dilatation under direct vision.

The extrinsic stenosis disappears with the removal of the tissue mass pressing on the trachea ; where the pressure has been long continued, dilatation under direct vision is required before the canal returns to normal.

Tuberculous or syphilitic stricture should receive general and local treatment.

Bronchoscopy in Non-tuberculous Diseases of the Lung. — The natural pulmonary defence may be considered : (1) Cough reflex, (2) Ciliary activity ; and (3) Germicidal action. The compression of the lung during a cough forces the secretion from the periphery of the lung, but it is the ciliary action which plays a great part in the upward drainage. In inflamed or in scar tissue, as when a lung abscess bursts into the bronchus or in a dilated bronchus in the case of a bronchiectasis, there is no ciliary action and there is consequent stagnation. To evacuate the secretion postural coughing has been tried, gravity helping the cilia ; but forced coughing in the upside-down position will not empty the cavities, as in the act of expectoration following the cough there is a sharp contraction of the bronchi, the cavity being suddenly closed ; it is thus impossible to empty completely the cavities of a lung abscess or of a bronchiectasis. Bronchoscopic drainage is better than natural drainage. Instead of leaving infective material to incubate in the bronchus it is removed by aspiration and, where the pus and secretion are too thick, aspiration is assisted by lavage.

The possibility that a lung abscess or a bronchiectasis may be the result of a foreign body must not be forgotten. The removal of a foreign body will cure 90 per cent of these cases.

The lung abscess or bronchiectatic cavity, especially where it is of the fusiform type, can be aspirated by means of an aspirating bronchoscope attached to a strong
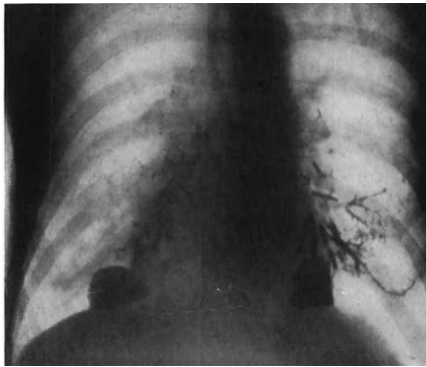
Fig. 130.—Lung abscess, both lower lobes affected.

suction apparatus. Through this aspirating bronchoscope a two-way cannula can be passed to the base of the cavity. A second suction apparatus attached to the cannula enables the cavity to be thoroughly sucked dry, and through the other arm of the cannula bland fluid such as boric lotion or normal saline can be pumped in and the cavity washed clean.

Afterwards, a cavity may be treated through the bronchoscope with various antiseptics, preferably absolute alcohol or an oily emulsion such as bismuth or iodoform. The aspiration and lavage of the bronchiectatic cavity or lung abscess give in many cases a complete cure of the disease. Where there is no immediate cure there is the greatest relief to the patient. The horrible odour of the breath, which is the usual accompaniment of a bronchiectasis, disappears, and the patient has a better outlook. The successive aspirations should be carried out at from two to four weeks interval.

Post-operative Collapse of the Lung.—In post-operative collapse of the lung, where the bronchi are suddenly plugged with a sticky secretion

causing a collapse beyond it, air will not enter until this block has been removed. Absence or diminution of the cough reflex is one of the factors in the production of a massive collapse along with a 'wet anæsthetic'. Sometimes this plug clears itself but in many cases it has to be removed through a bronchoscope.

In the taking of radiographs of the chest, bismuth or lipiodol can be injected directly through the bronchoscope into the part of the chest involved, so that there may be a more definite localization of the areas to be outlined. (*Figs.* 130, 131.)

Fig. 131.—Normal chest. Radiograph after the injection of lipiodol through the bronchoscope.

Tumours Affecting the Lung.—There are many intrathoracic tumours which need not be discussed in this section. The bronchoscopist must confine himself to the trachea and bronchus. On direct examination the alveoli of the lung cannot be inspected, but examination of the adjacent bronchus is sufficient.

These intrathoracic tumours can be divided into malignant and non-malignant growths, but it must be remembered that certain benign growths in the bronchus will prove fatal by obstruction to ventilation or drainage. These tumours, benign or malignant, primarily starting in the bronchus, show no physical signs, apart from occasional hæmoptysis. capable of detection by the physician or radiologist.

1. The diagnosis of this group depends on bronchoscopy.

2. These growths which start outside the bronchus or around the bronchus show physical signs like an early tubercle, and clinically can be tentatively diagnosed and confirmed by the radiological examination. From the bronchoscopist's point of view this group is associated in its early stages with rigidity and deformity of the bronchus, although later on there is an involvement of the bronchial mucosa ; a piece can then be removed from the bronchus for pathological report.

3. A combination of these growths is probably a late manifestation of one or the other.

Benign growths such as papilloma, lipoma or hæmangioma can be readily diagnosed by means of the bronchoscope.

There are no physical signs absolutely characteristic of a new growth in the lung, and it is this factor which makes the early diagnosis of intra-thoracic tumours so difficult.

During the last two years Chevalier Jackson in the bronchoscopic clinic in Philadelphia has found that many patients suffering from carcinoma of the lung have shown an asthmatoid wheeze, extremely like that which one associates with a foreign body in the bronchus or trachea. This wheeze is produced by an obstructive narrowing of some point of the lumen of the trachea or bronchus, or is due to a thick tenacious secretion which is being held up by some want of ciliary movement in the lining membrane of the lower air-passages. " All is not asthma that wheezes," Jackson has been said to remark. This asthmatoid wheeze should be taken as a definite indication for bronchoscopic examination. It is really only with the advancement of endoscopic diagnosis that radiographic diagnosis has been able to play the part it does. The radiograph of an early carcinoma of the lung is a most difficult one to read. Cases of cancer of the lung have been admitted to a sanatorium with clinical and radiographic diagnosis of advanced tuberculosis, and only their rapid fatal termination has allowed of post-mortem diagnosis.

Statistics indicate that the majority of malignant growths in the lung begin in the mucosa of the trachea or bronchi and may early occlude the whole bronchus and cause a collapse of the lung.

TREATMENT.—It would seem possible to remove the early endobronchial tumours through a bronchoscope. Cases have been reported by Jackson and von Eicken when a local removal has given the patient freedom for some years, but this can only be possible when the diagnosis is immediate. As regards other forms of treatment, the endoscopist must, along with the physician and radiologist, admit failure. Local applica-tion, radium seeds or capsules through a bronchoscope, have not given the hoped-for results. Deep X-ray therapy prolongs life but has not proved a cure. One would suggest that radium seeds or capsules should be put into the tumour by means of a bronchoscope, and later the thoracic surgeon should irradiate the lung externally after a thora-coplasty.

Lobectomy is now possible with a reasonably good prognosis, and should be the operation of choice in an early case.

DIRECT EXAMINATION OF THE ŒSOPHAGUS.

Œsophagoscopy.—A full description of œsophagoscopy is beyond the scope of this book. The œsophagus can only be inspected by the direct method, as with the laryngeal mirror only a small portion of the lower pharynx can be seen behind the arytenoids which effectually conceal the mouth of the gullet.

The patient complaining of pain on swallowing, but who shows no evidence of anything wrong on indirect laryngoscopy, should always be examined with the œsophagoscope after a preliminary X-ray and, if necessary, a bismuth meal. Difficulty in swallowing may be the result of a foreign body, œsophageal pouch, cardiospasm, or benign growths. As age advances, the cause may be malignant disease of the œsophagus which is not uncommon, or there may be a mediastinal neoplasm pressing on the œsophagus. By œsophagoscopy, simple, traumatic, malignant or specific strictures can be diagnosed and treated.

No condition of difficulty in swallowing, even though everything points to its being hysterical or functional, should be regarded as such, until a direct examination of the œsophagus has been carried out. Most of the spasmodic or functional affections of the œsophagus have some small organic cause which may admit of treatment.

Before any direct examination of the œsophagus is made, the chest should be thoroughly examined, so as to exclude the possibility of aneurysm or mediastinal growth, the presence of which might be a contra-indication to the passage of the œsophagoscope.

The œsophageal bougie or sound should never be passed unless under direct vision, because the walls of the œsophagus are easily ruptured, such an accident being followed by a fatal mediastinitis. The coincatcher and probang bougie are now things of the past. These instruments were devised for the blind removal of foreign bodies from the œsophagus, and they proved more often fatal than the foreign body for the removal of which they were intended, as they readily damaged the œsophagus.

An X-ray examination with a bismuth meal will show whether the swallowing of food is interfered with, and the region involved. The bismuth, moreover, will coat and demonstrate a non-opaque foreign body. It will outline abrasions of the œsophagus and thus indicate an area of ulceration, whether malignant or simple. It will demonstrate if there is any spasm of the œsophagus, by being held up momentarily, and then suddenly passed on towards the stomach. Such an examination, however, must only be considered as supplementary to direct œsophagoscopy.

OPERATION.—The patient is prepared in the same way as for direct laryngoscopy or bronchoscopy. Where there is frequent regurgitation of food, the patient can be made to empty the œsophagus as much as possible by tickling the hypopharynx beforehand with the finger, or the œsophagus may be washed out with an ordinary stomach tube before the operation but in most cases it is better to wash out the œsophagus through the œsophagoscope.

No attempt must be made to pass the œsophagoscope blindly. It must be done under direct vision as in the case of bronchoscopy. There is no need to attempt to pass too big a tube. Quite a good view of the œsophagus can be obtained through a 9 or 10 mm. tube if distally lighted. Proximal illumination, however, usually requires the use of a larger tube which may cause the patient some discomfort.

It is necessary in passing the œsophagoscope to follow the curves of the cervical and dorsal spine (*Plate XIV*, E and F). To do this, the assistant holding the head must follow the movements of the œsophago-scope as it reaches the different levels of the œsophagus. The instrument is held lightly in the right hand between the finger and thumb ; the left hand retracts the upper lip, and the tip of the œsophagoscope rests lightly in the fingers of the left hand, with the middle and ring fingers hooking over the upper teeth. With the head in practically the same position as for laryngoscopy, the œsophagoscope is passed down the right side of the tongue and the posterior pharyngeal wall into the right pyriform sinus, where it comes to a stop at the cricopharyngeal con-striction. To get the œsophagoscope over the cricopharyngeal muscle is the most difficult movement in œsophagoscopy. Force must never be used. It is easy with the tip of the œsophagoscope to tear the mucous membrane above the cricopharyngeal muscle, thus making a false pas-sage behind the œsophagus. It is in this region that the blind passage of an œsophageal bougie may tear the œsophageal wall and cause mediastinitis.

The simplest way to overcome the cricopharyngeal muscle is by pressing firmly against it with the slanted end of the œsophagoscope facing downwards, at the same time levering the distal end of the œsophagoscope upwards with the thumb of the left hand as it rests on the teeth. Once beyond the cricopharyngeal muscle the œsophago-scope glides easily through the thoracic œsophagus to the level of the aorta and then to that of the left bronchus, the walls of the œsopha-gus, opening up in front of the œsophagoscope, being carefully watched as the tube passes down. When this level is reached, the head must be dropped so that the tube may follow the line of the dorsal spinal curve until the little rosette slit comes into view, the diaphragmatic hiatus.

Difficulty may be experienced with the constant flow of gastric juice during the examination ; this can be readily overcome with the suction apparatus attached to the aspirating tube of the œsophagoscope. The œsophagoscope must never be forced downwards.

Once inserted, the œsophagoscope should not be removed until the completion of the operation. In many clinics, however, it is found easier to examine the upper end of the œsophagus with an œsophageal spatula, such as in the modified Lynah's or Jackson's upper-end œso-phagoscope, and afterwards to inspect the lower end with the long œsophagoscope. The upper-end œsophagoscope, however, should never be used where the history and X-ray examination point to a lower-end lesion, as the changing of the tube means unnecessary discomfort to the patient.

The œsophagus is a relatively long, easily distensible tube loosely attached to the surrounding tissues and, when affected, gives rise to very few local symptoms. Pain is usually referred to its upper or lower end, that is, to the pharynx or to the stomach ; but there is one predominant symptom—*difficulty or discomfort in swallowing.* There is naturally a slight difference in the symptoms according to which end of the œsophagus is affected.

The commonest complaint of a patient suffering from an affection of the upper end of the œsophagus is difficulty or pain on swallowing, and regurgitation of food. The onset of dysphagia may be gradual, the patient finding it difficult or impossible to swallow solid foods which he has to wash down with copious draughts of liquids. Later, he finds that he can swallow only soft foods, then liquids and finally not even saliva. If the lesion is at the upper end, there is very often a slight escape of food into the trachea, followed by fits of coughing. The onset of dysphagia may be sudden, a symptom which is usually associated with spasm of the œsophagus ; but it is not uncommon to find an element of spasm associated with, and often heralding, malignant disease of this region. Pain or discomfort, especially behind the thyreoid, is sometimes complained of, and sometimes pain shooting up to the ear. Very often increased salivation is a symptom of an affection of the superior opening of the œsophagus. In some cases dysphagia is absent, and the patient may complain of an excessive mucous secretion.

In affections of the lower end of the œsophagus dysphagia is a prominent symptom, while regurgitation of food is usual. The patient often complains of hiccough, a feeling of weight over the stomach, excessive salivation, or a sensation of choking.

Symptoms are sometimes referred to the upper end of the œsophagus, and from symptoms alone it is almost impossible to tell whether the lesion is at the upper or lower end. In the case of the former, a spasm is often associated with some trauma ; a spasm of this region is in many cases purely hysterical, or may be associated with malignant disease. At the lower end the spasm is usually associated with cicatricial contraction, malignant disease, compression from without or 'cardiospasm'.

The symptoms of œsophageal disease are so often stomachic in character that all cases of vague gastric symptoms with no apparent local cause should be œsophagoscoped to eliminate the presence of an œsophageal disorder.

Diverticula or Pouches of the Pharynx and Œsophagus.—These are etiologically classified into *traction* and *pulsion* diverticula. The traction diverticulum is rare, usually situated within the thorax and follows the cicatricial adhesions of the œsophagus to the surrounding tissues from some inflammatory, tuberculous, or traumatic cause. Constant movement of the œsophagus, pulling on these adhesions, forms small diverticula which give rise to few or no symptoms ; these are only discovered on endoscopic examination, or on X-ray examination with a bismuth meal.

16

The pulsion diverticulum is probably a hernial sac, driven out where the wall is weakest by pressure in the downward passage of food.   It is usually small, though in some cases it is large enough to cause swelling in the side of the neck.   The weakest part is probably the posterior wall of the lower pharynx, and it is in this region that the pouch usually arises ;   hence these diverticula, which occur commonly in adult life, are really an affection of the lower pharynx, and not of the œsophagus : but the symptoms are purely œsophageal.   There is gradually increased difficulty in swallowing ;   eating is accompanied by a feeling of fullness in the neck, only relieved when some of the food is regurgitated.   Shortly after eating, the patient brings up undigested food, though in some cases
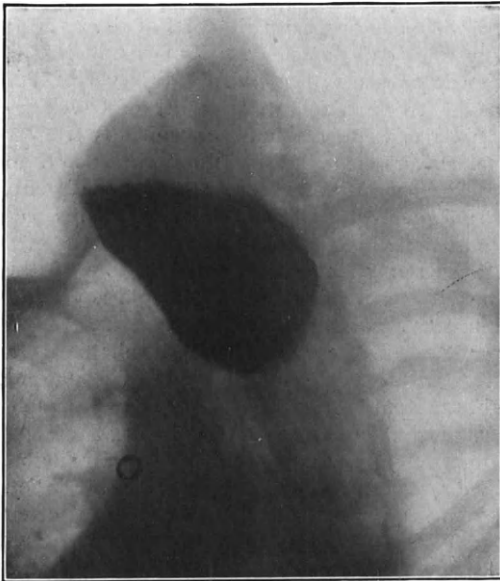
Fig. 132.—Radiograph of œsophageal pouch after opaque meal.

the food is retained for days in the pouch, which may then empty itself suddenly, giving relief to the constant feeling of fullness in the. neck.   As the pouch gets bigger, it pulls downwards on the œso- phagus, and closes the œsophageal mouth, so that   swallowing becomes more and more difficult.   The patient, later on, is only able to get nourishment by eat- ing very little at a time, or by voluntarily evacuating the pouch several times during a meal.

On examination with the laryngeal mirror, sometimes both pyri- form sinuses are seen full of frothy fluid ; but diagnosis can only be verified by screening with bismuth (*Fig.* 132) or by an œsophageal examination ;   the mouth of the œsophagus being very difficult to make out, the œsophagoscope can be passed easily into the pouch.

TREATMENT can be carried out through the œsophagoscope where the pouch is small, by constantly dilating the mouth of the gullet, or by cutting through the common boundary wall, as suggested by Mosher. In large pulsion diverticula, the only successful treatment is by means of an external operation for removal of the sac, preferably in two stages.

Strictures of the Œsophagus.—These, as in any other region of the body, may be simple, traumatic, malignant, or due to extrinsic pressure,

either simple or malignant. Congenital stricture of the œsophagus has been shown to be not uncommon. Malformations, fistulæ and atresiæ are rarely diagnosed outside the post-mortem room.

Simple Fibrous Stricture of the Œsophagus may follow the swallowing of caustic liquids, such as phenol preparations or lye, or may result from ulceration due to injury by a foreign body. At the lower end of the œsophagus peptic ulcers very often cause stenosis or set up a spasmodic contraction. Ulceration following diphtheria, typhoid, tuberculosis, syphilis, scarlet fever, and pyogenic inflammation has been described as a cause of fibrous strictures.

The commonest situation for traumatic cicatrization of the œsophagus, following the swallowing of caustic liquids, is probably the middle third. though both the upper and lower ends may be affected, and very often the strictures are multiple. The symptoms are those of any œsophageal affection, the patient complaining of difficulty in swallowing, of cough, and regurgitation, the distress after eating being only relieved by regurgitation.

DIAGNOSIS. — This can readily be made by direct examination, associated with the use of the fluorescent screen and a bismuth meal (*Fig. 133*).

TREATMENT necessitates frequent dilatation over a prolonged period, by the passage of bougies through the œso-

Fig. 133.—Radiograph showing stricture of upper end of œsophagus, the bismuth meal trickling through the stricture.

phagus under direct vision. Blind attempts at dilatation are most often followed by rupture of the œsophagus.

Malignant Disease of the Œsophagus is now more frequently met with. It is usually of a carcinomatous nature ; sarcoma does occur. The etiology of the disease is still uncertain ; age and irritation seem to be the only probable factors.

The special irritant factors in the case of the œsophagus are: (1) Those incidental to the passage of food, including the swallowing of irritants; (2) Regurgitation of the acid contents from the stomach ; (3) Stagnation and consequent fermentation. Cancer is more frequently found in the lower third of the œsophagus where these factors may be present. It used to be stated that cancer occurred most commonly at one of the four constrictions of the œsophagus, but clinical experience during

the last few years points to the lower third as being a more common site than the upper two thirds.   (*Plate XV*, A, B, C.)

Cancer at the upper constriction—that is, in the post-cricoid region—is certainly more common in females ; whether tea drinking or the use of hot fluids irritating this region have anything to do with the onset of cancer, it is difficult to say.   In China, where the staple diet is rice, cancer is commonest at the upper part of the œsophagus in males who are served with the hottest portion.

Œsophageal cancer still continues to be rarer in women than in men. The common age for the onset of cancer of the œsophagus is between 45 and 50, but cases have been described at the age of 19.   Sarcoma, of course, occurs at any age from 6 upwards.   A squamous epithelioma is the commonest type found in the œsophagus but at the lower end an adenocarcinoma occurs arising from the stomach and growing into the œsophagus.

Gradual increasing difficulty in swallowing is the common symptom ; usually before the patient complains of this difficulty in swallowing there is a vague discomfort ; a queer feeling in swallowing ; a nervousness in starting to swallow ; a feeling that more muscular effort is required to help the food down the œsophagus ; a feeling of food sticking when eating in a hurry or of occasional pain in the back on swallowing quickly.

Pain referred to the side of the neck or ears is a late symptom.

In post-cricoid carcinoma and in the other regions pain again is a late symptom and may be referred to the back or to the stomach.

Later on the patient may develop symptoms due to pressure on the trachea or bronchi.   Without treatment there is always rapid emaciation and death occurs in six months' time.

Cough is an early symptom of cancer of the œsophagus and is often overlooked.   It is present when the upper third of the œsophagus is involved where there is pressure on the trachea and bronchi.   X-ray examination after a bismuth meal will reveal how the œsophagus is functioning ; as to whether there is delay in the passage of food or ballooning of the œsophagus ; it will reveal the presence of any stricture. Patients should be screened with the bismuth meal, first in the upright position and then in the semi-reclining position, as the passage of food can be more easily seen in the latter ; lastly, in the modified Trendelenburg position so that the bismuth can flow up the œsophagus and outline the lower end of the stricture.   Œsophagoscopy permits of a final verdict; the size and extent of the growth can be seen and the condition of the œsophagus round the growth investigated.   Fixation of the œsophagus usually means that there is mediastinal infiltration.   A piece can be removed for pathological report.   There is only one condition with which cancer of the lower end of the œsophagus can be confused and that is a peptic ulcer, but a peptic ulcer in this situation is very rare.   Minor mucosal erosions are not common and they do not have the typical thickened edges and do not bleed so readily as a new growth.

In post-cricoid carcinoma there is very often a sudden onset of the symptoms.   There may be sudden obstruction following the sensation as if a bone or a piece of meat had lodged in the gullet.   On the other

PLATE XV

AFFECTIONS OF THE ŒSOPHAGUS
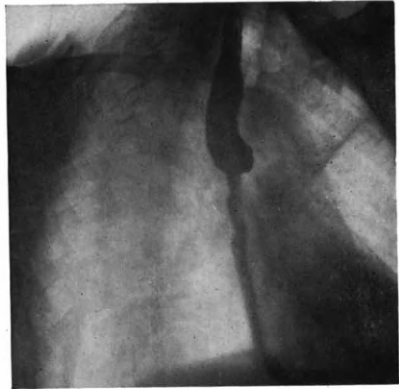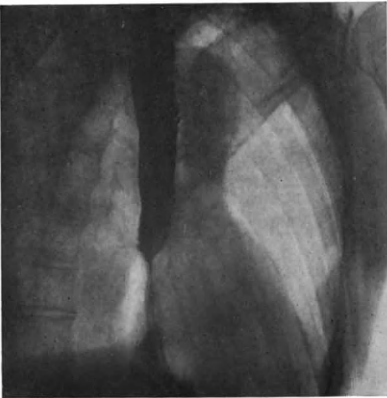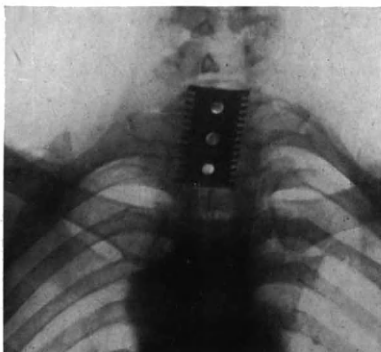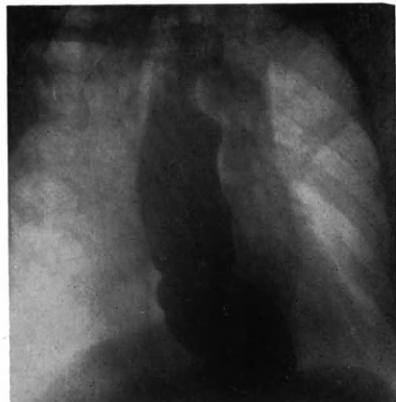
(A) Cancer of the œsophagus, upper third; (B) Cancer of the œsophagus, middle third;
(C) Cancer of the œsophagus, lower third; (D) Congenital shortening of the œsophagus;
(E) Foreign body in the œsophagus (razor blade); (F) Cardiospasm.

hand the patient may complain of excess of mucous secretion or of a slight hoarseness before she complains of difficulty in swallowing. Hoarseness is usually a late symptom due to invasion of the larynx. In women over the age of 35 and in men over the age of 40 with the complaint of slight difficulty in swallowing, even with the onset referred to the swallowing of a fruit stone, small piece of bone or a crust of bread, the possibility of early malignant disease should not be forgotten and careful X-ray examination should be carried out. In these cases œsophagoscopy is called for. In many cases where difficulty in swallowing is complained of and the X-ray findings are negative, œsophagoscopy is demanded. Certain cases show a curious glossiness of one or both sides of the tongue due to absence or atrophy of the papillæ, although its causal connection is obscure. Often in advanced cases it is possible with a laryngeal mirror to detect a slight œdema or even ulceration of the posterior surface of the arytenoids. In other cases where the lesion is low down one can detect with a mirror excess of secretion in one or other of the pyriform sinuses.

Abductor paralysis of the right vocal cord may be observed when the upper end of the œsophagus is affected : on the other hand, when the disease is situated lower down in the gullet, the paralysis may be on the left side owing to the position of the left recurrent laryngeal nerve in relation to the œsophagus.

Routine examination includes: (1) History with an attempt to make the patient think back ; (2) Examination of the mouth and tongue, the tongue often showing an atrophy of the papillæ; (3) Examination of the larynx, want of mobility, paresis of the cords, etc. ; (4) Inspection of the pyriform sinuses for excess of secretion ; (5) General examination of the chest and heart ; (6) Wassermann test ; (7) X-ray examination— screening, then screening during the passage of a bismuth drink and lastly radiographing after a bismuth meal ; (8) Œsophagoscopy and the removal of a piece of tissue for histological report if necessary.

TREATMENT.—The cervical portion of the œsophagus is accessible to the surgeon, so that cancer of the upper end of the œsophagus (post-cricoid carcinoma) can be eradicated by surgical interference. Early diagnosis is essential. It may be that a total laryngectomy must be performed, but there should always be the possibility of a complete cure. Complete surgical removal of the œsophagus has been attempted, but so far the only real successful result of surgical removal is the famous case of Torek, whose patient lived for thirteen years with external rubber acting as an œsophagus. Grey Turner recently showed a brilliant and successful case, which, however, did not long survive the artificial œsophagus. Attempts at removal of portions of the œsophagus by transpleural or extrapleural routes have not met with great success ; in almost every case diagnosis has been too late.

It seems that radium or deep X-ray therapy holds out the only hope of obtaining a cure, while palliative treatment must be undertaken early to prolong the life of the patient.

Frequent dilatation of the affected area under direct vision has been suggested by Chevalier Jackson. A popular palliative method of treatment

of recent years has been the use of Souttar's tubes; little flexible tubes of German Silver spiral wire are introduced into the stricture and may remain in position for almost a year.

Radium held in position by bougies over the affected area for the necessary period, followed by deep X-ray therapy, seems to be the best method of treatment. Radium needles introduced into the growth, or radon seeds, have not given the expected results. Application of large daily doses of X rays through multiple long narrow fields placed at intervals round the chest wall, the fields being long owing to the tendency of the disease to spread, and narrow so as to allow of a number of fields, has probably given the best results of all.

If the cancer of the œsophagus is intrinsic it may be eradicated and, as glandular spread is apparently a late occurrence in cancer of the middle two thirds of the œsophagus, early diagnosis affords a possibility of cure.

Cardiospasm.—There are so many opinions as to the etiology and pathology of so-called cardiospasm, and there are probably so many different diseases which eventually may be separated one from another but are now still included under the term cardiospasm or achalasia, that detailed description is impossible.

The term cardia is applied to the junction of the stomach and the œsophagus; above this there is a definite canal extending about half an inch which can be divided into three sections, the abdominal, the diaphragmatic and the hiatal œsophagus. There is no sphincteric muscular arrangement at the junction between the œsophagus and stomach, so the term cardiospasm is really a misnomer; but it is applied generally to the spasm at the lower end of the œsophagus which various writers term functional, hiatal, stenotic, œsophagismus, or phrenospasm. It is in the hiatal region that the spasm is seen by direct examination.

Some authorities, such as Hirst in this country, recommend the passing of mercury bougies which require to be passed before each meal at the beginning of treatment if the condition is severe, and the intervals of passing the bougie can be lengthened until the tube is passed once daily and then once weekly. This treatment fails unless it is rigorously supervised, as the bougie in many cases passes into the pouched dilated œsophagus round the ' hiatal pinch cock ' and not into the cardiac end of the stomach. Gradual mechanical dilatation of the hiatal œsophagus carried out under direct vision has given very good results. The dilatation must be gradual and at frequent intervals to begin with, and each treatment is followed by a period of twenty-four hours' starvation to allow of the recovery of the dilated œsophagus. Retrograde finger dilatation of the cardiac end of the stomach through a gastrostomy opening has been tried but the results are not satisfactory. Lately a form of continuous dilatation has been suggested by Tucker, of Philadelphia, when a small olive bougie is passed downwards and upwards through the cardiac end. Lately the resection of the sympathetic nerves accompanying the left gastric artery has been carried out with excellent results in some cases.

DIAGNOSIS.—The onset of the disease is slow, exciting little attention, so that the diagnosis is very rarely made early in the disease. The

patient usually complains of a sensation of weight in the epigastrium after meals, which is often relieved by drinking water. Sometimes after meals there is a slight regurgitation of food which at once relieves the feeling of heaviness; food is returned unaltered. The patient has usually been taking gastric sedatives for some time, in the belief that he is suffering from indigestion. The symptoms gradually become more pronounced, with impairment of general nutrition. The œsophageal dilatation may be so great that regurgitation, instead of recurring immediately after each meal, does not occur until some time afterwards, when stale or decomposed food is brought up.

SYMPTOMS.—In its symptoms cardiospasm sometimes resembles an œsophageal pouch, though in the latter case the regurgitation of food may often be brought about at the will of the patient. The patient is often able to tell when the œsophagus is open or closed, and will some-times eat without hesitation, and know when to refuse food. Sometimes there may be no trouble for weeks at a time and then, suddenly, at the beginning of a meal, the food is held up and the patient gets no rest until the food is regurgitated or sometimes brought up into the mouth and reswallowed. In advanced cases the patient is afraid to take a meal in public, fearing lest there may be regurgitation setting up a a spasm of coughing, and very often actual vomiting. Most patients complain of discomfort in the region of the cardia, although in some cases there is nothing but the sensation of fullness in the throat. In the later stage there is a dragging, gnawing pain in the epigastrium, very often simulating a gastric ulcer.

The diagnosis of 'cardiospasm' can be readily made by means of X-ray and endoscopic examination. With the œsophagoscope, the ballooning of the œsophagus above the spasm is readily recognized. Masses of soft food collected in the bottom of the œsophagus have to be picked or washed out. The lower part of the œsophagus may be seen sagging, so that the hiatus may appear to be at a higher level than the fundus of the dilatation. In very advanced cases it is difficult at first to locate the hiatus. The possibility of an organic lesion being present must be excluded.

Some believe that more than 75 per cent of cases of cardiospasm are due to an organic lesion. It is very often difficult to exclude the possibility of ulceration either malignant or benign. In some cases such a condition in the fundus or lesser curvature of the stomach may be the cause of an œsophagismus. (*Plate XV*, F, p. 244.)

TREATMENT.—Where there is no apparent organic lesion, dilatation by bougie or by mechanical dilators of the Mosher or Gottstein type is usually all that is necessary, although there may have to be several dilatations. Certain cases prove very obstinate and may require washing out through a stomach tube, and even retrograde dilatation with the fingers through the gastrostomy opening. After dilatation the patient must pay very particular attention to proper mastication of food, and to abstention from hurried meals and from too hot or too cold foods.

Paralysis of the Œsophagus.—This is rarely met with in its complete stage. It may, of course, be motor or sensory. Swallowing is interfered

with ; œsophageal secretion wells up into the pyriform sinuses and over-flows into the larynx. There may be inability to swallow owing to the lack of the necessary reflex impulse. A slight paresis with indifferent symptoms is comparatively unknown.

TREATMENT.—Local treatment is useless ; but the patient must be fed, either through a tube passed into the stomach through the mouth, or through a gastrostomy tube.

Infections of the Œsophagus.—Ulceration is rare. Superficial erosions are not uncommon and very often lead to cicatricial contractions or, by a local irritation, set up a spasm of the œsophagus. The symptoms and signs are those of a stricture of the œsophagus. The erosions are usually due to the downward passage of a foreign body, such as a fish- or meat-bone swallowed during a hurried meal.

Œsophageal abscess, which is also a somewhat rare condition, follows traumatism due to the impaction of a foreign body ; very often it is caused by injudicious attempts at the removal of a foreign body. Its commonest situation is in the upper third of the œsophagus, and it is most often succeeded by a mediastinitis which is almost always fatal. The œsophagoscope is essential in diagnosis ; pus can be evacuated through the tube, though in many cases a lateral œsophagotomy is necessary.

Injuries to the Œsophagus.—Trauma and even rupture of the œso-phagus may ensue from the passage of an instrument or foreign body, or from both, as often happens in the blind attempt to remove a foreign body with a bougie or probang, the foreign body being pushed through the œsophagus.

Perforation of the œsophagus may follow the swallowing of a crust of bread or any other hard food when there is stagnation of regurgitated gastric juice in long-standing toxic or debilitated conditions.

Rupture of the thoracic œsophagus is followed by shock, fever and an acute mediastinitis. Pneumothorax and empyema may follow perforation into the pleural cavity. Rupture of the cervical part of the œsophagus may be followed by a deep cervical abscess, sometimes seen after the perforation of the posterior cricoid region of the œsophagus by a fish-bone actually swallowed.

TREATMENT.—The treatment of these cases of trauma consists in absolute rest in bed, no food of any kind being taken by the mouth for at least four days, the patient being kept on rectal feeding and salines. After the fourth day sterile liquids or sterile meat jellies can be given by the mouth, gradually passing on to normal diet, if the patient does not complain of pain or discomfort.

Complete rupture of the œsophagus calls for an early gastrostomy so as to put the œsophagus entirely at rest.

CHAPTER XXXI.

FOREIGN BODIES IN THE AIR- AND FOOD-PASSAGES.

THE types of foreign body are almost endless and their enumeration is unnecessary. Many of the foreign-body accidents are entirely preventable ; but it is surprising that these accidents are not more common when one considers how often pins, tacks, or hairpins are held in the mouth while the mind and hands are occupied with something else.

The natural tendency in young children is to carry any portable object to the mouth ; while older children are continually experimenting on the feel of different objects with their teeth. In children, probably, the protective reflex action is not so efficient as in the adult, and objects held in the mouth slip into the œsophagus much more easily, or are inhaled into the air-passages.

The foreign body reported as 'swallowed' may have entered the œsophagus and remained there, or passed on through the alimentary canal ; or it may have been inhaled and remain in the upper or lower air-passages. The immediate symptoms following the accident can only give a clue to its position. It is of the first importance to find out whether or not there was a cough or dyspnœa at the time of the accident, followed by blood-stained expectoration. The absence of coughing strongly negatives the possibility of the foreign body having entered the air-passages, and supports the probability of its having passed into the alimentary canal ; even the smallest foreign body remaining in the œsophagus causes pain on swallowing and very often a reflex cough.

THE AIR-PASSAGES.

Foreign bodies can only enter the air-passages after some interference with normal reflex action, such as the sudden indrawing of the breath in fright or laughter, causing the inhalation into the larynx or tracheo-bronchial tree of food particles or other objects held in the mouth. The foreign body may be held up at the epiglottis, or at the glottis by the ventricular and vocal folds, or again it may be prevented from entering the lower air-passages by the immediate reflex cough, though in some cases a sudden inspiration, which precedes the reflex cough, draws the foreign body into the bronchus.

The ventricular and the vocal folds have a sphincter-like action in catching and preventing foreign bodies from entering the trachea ; but, here again, inspiration may precede the reflex cough, open the glottis and allow the foreign body to enter. A metallic foreign body may remain

in the trachea or bronchus for some time with very few symptoms, if it does not appreciably obstruct the airway. On the other hand, vegetable matter, such as a nut-kernel, in its decomposition, usually sets up a violent local reaction in the trachea or bronchus.
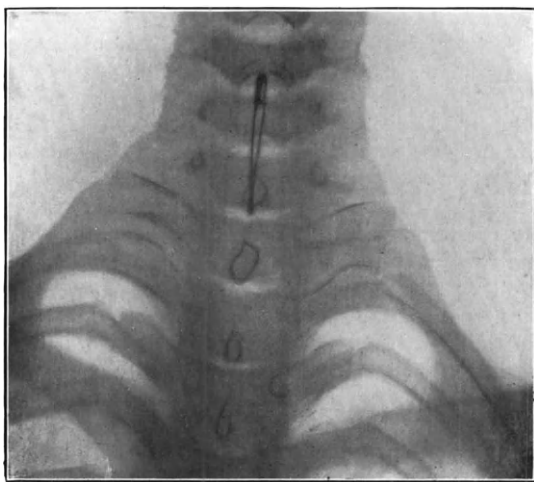
Fig. 134.—Foreign body (safety-pin) in subglottic region of the larynx, showing position of flattened body held up in the larynx and trachea in an antero-posterior view.

The Larynx. — A foreign body in the larynx is readily diagnosed ; the patient, coughing and choking, is unable to speak, and points to the front of the larynx as the seat of the pain. A history of the accident is easily obtainable. There is usually no time to obtain a radiograph (*Figs.* 134, 135), as a foreign body in the larynx calls for urgent removal. This is possible sometimes by the indirect method, but direct laryngoscopy gives an easier mode of access. When there is obstruction to breathing, with cyanosis, and when the indirect or direct method is impossible at the moment, the circumstances call for an immediate tracheotomy, followed later by the removal of the foreign body from the larynx when the danger to life has passed.

The Trachea and Bronchus. — In the trachea or bronchus, diagnosis is more difficult. There may be

Fig. 135.—Foreign body (safety-pin) in subglottic region of larynx, showing position of flattened body held up in the larynx and trachea in a lateral view.

no history at all of the accident ; the child may, through fear of punish-
ment, conceal the fact that he has swallowed something ; the adult
may inhale or swallow a foreign body during sleep or when intoxicated.
There may be a history of the inhalation of a foreign body, but no
symptoms until some weeks afterwards.   The possibility of a foreign
body lying dormant for some time must not be forgotten.   In several
cases a history is obtainable, and symptoms are present ; but the
symptoms may be only due to a scratch in the downward passage of
a foreign body.   An X-ray photograph should be taken in all cases of
suspected foreign body in the air-passages.   The antero-posterior view
is not sufficient ; a
lateral view of the
neck should be taken,
there being always the
possibility of a small
foreign body lodging
behind the   cricoid
cartilage.   In a few
cases a non-opaque
foreign body in the
trachea may be de-
monstrated   on   the
radiographic   screen
after the insufflation
of bismuth, which will
coat   both sides of
the trachea and the
foreign body.

In radiographic in-
terpretation it must
be remembered that
when a foreign body
is lodged loosely in
the bronchus air can
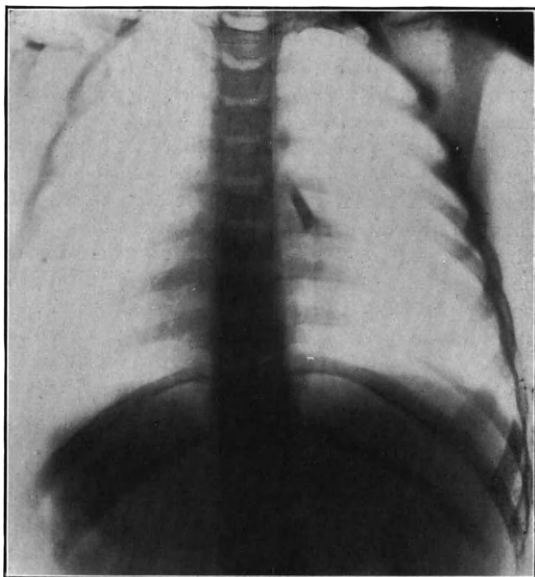
Fig. 136.—Foreign body (whistle) in bronchus.

enter the lung along
the bronchus during the acts of inspiration.   During expiration the
bronchus contracts on the foreign body and the air cannot pass out ;
consequently an obstructive emphysema takes place.   Later on, irritation
of the mucosa round the foreign body causes swelling so that air can
neither enter nor escape, with consequent collapse of the lung.   In the
early stages of an inspired foreign body there is a descent of the dia-
phragm and transparency of the lung on the side in which the foreign
body is lodged.   In the later stages the diaphragm will be higher and
the heart will be pulled across to the side of the foreign body owing to
collapse of the lung below the obstruction.

In most cases of non-opaque foreign bodies in the bronchi more reliance
must be placed on the physical signs in the chest—signs which resemble
in many ways a chronic phthisis.   In cases showing such signs, and in
which no tubercle bacilli are found in the sputum, the presence of a foreign
body should be suspected.

The old classical signs of foreign body in the bronchus are rare, e.g., attacks of choking, laryngeal 'click' due to a body fixed in the larynx, and the loud flap of a foreign body loose in the trachea. The findings at the physical examination, however, are quite distinctive ; most commonly there is a marked diminution of the respiratory murmur, together with the preservation or accentuation of the normal resonance, and dry râles limited to a particular area—indeed, the inflammatory signs of a localized bronchitis.

In 1918, Chevalier Jackson published an account of a new diagnostic sign for foreign body in the trachea and bronchus—'the asthmatoid wheeze', the sound being somewhat similar to the wheezing heard when the ear is placed to the open mouth of an asthmatic patient. The chief difference is that râles are more or less associated with the wheezing in asthma, while in the asthmatoid wheeze of the foreign-body case the sound is drier, though it may be associated with some secretion adding more or less of a bubbling sound. The sign is of no localizing value, but it gives a hint of the presence of a foreign body. Chevalier Jackson describes the special form of bronchitis due to inspiration of peanut-kernels and a few other organic substances into the air-passages. The chart shows an irregular temperature of hectic type, the heart and res-piratory rate being higher in proportion to the temperature, as would be expected. There is a dusky cyanosis, often superseded by an intense pallor, probably the result of the excessive heart-strain incident to the strenuous efforts of the muscles of respiration.

Very few foreign bodies in the trachea or bronchi call for removal under some hours. Delay is not so dangerous as in the case of a foreign body in the larynx. An X-ray (*Fig.* 136) should be taken with a view to diagnosing its position ; or if the suspected foreign body is non-opaque, the chest should be thoroughly examined in an attempt at localization. Morphia should be withheld if possible, as it reduces the cough reflex, which helps to clear away any secretion in the lower bronchi.

In cases of marked dyspnœa where the possibilities of the promptness of bronchoscopy are remote, a tracheotomy is advisable. There are no absolute contra-indications to bronchoscopy and œsophagoscopy in foreign-body cases, though certain conditions may justify postponement for a day or two.

THE ŒSOPHAGUS.

The retention of a foreign body in the œsophagus depends on the size and shape of the foreign body; the irregular toothplate, or the open safety-pin, or the large bolus of meat or large fish-bone easily finds lodgement. In some cases there is a narrowing or spasm of the œsophagus. which plays its part in the holding up of a foreign body.

Alternately the lodgement of a bolus of food in the œsophagus is suggestive of the presence of a pre-existing narrowing of the lumen of an organic nature and in all probability a commencing malignancy. A large bolus of food, poorly masticated and hurriedly swallowed, may be impacted in a perfectly normal œsophagus.

A foreign body of sufficient size is usually arrested in the cervical œsophagus at the superior aperture of the thorax.   A narrowing is present at this level immediately below the cricoid cartilage, produced in part by a muscular contraction but mainly by the crowding of the adjacent structures into the fixed and narrow aperture of the thorax.   If it is dislodged from this position the foreign body passes downwards to be arrested at the next narrowing, though it usually passes right into the stomach.

The endoscopist who encounters the difficulty of introduction of the tube over the cricopharyngeal fold might expect to find a foreign body here ;   such, however, is rarely the case.   The cricopharyngeal muscle
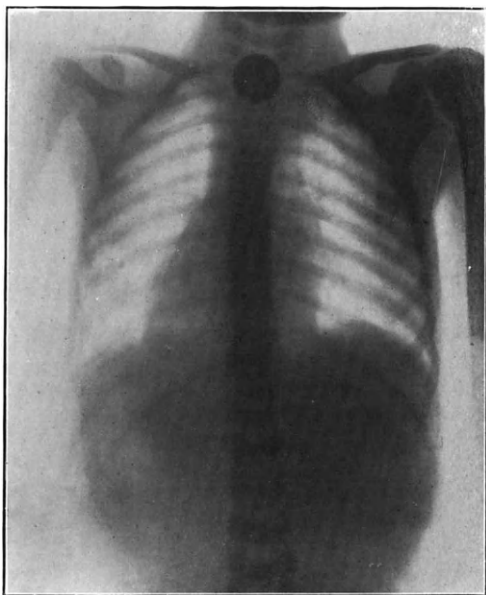
Fig. 137. — Halfpenny in œsophagus, showing position taken by flattened body in the upper end of the œsophagus in an antero-posterior view. It is impossible for a flattened body of this size to be lodged in this plane in the trachea.

really starts the foreign body on its way down, but it is held up at the narrowing of the thoracic aperture, as the œsophageal peristaltic muscula-ture is feeble compared with the powerful inferior constrictor.

The symptomatology is vague.   In the case of a large foreign body, there may be complete inability to swallow even water, but with regur-gitation of food.   This is sometimes the case even with a small foreign body.   But if there is a history of the swallowing of a foreign body, it must be somewhere in the alimentary canal, and an X-ray picture will at once clear up its situation (*Fig.* 137, and *Plate XV*, E, p. 244). If it is non-opaque, a thin bismuth meal should be given before an

X-ray examination, as this will coat the object and thus demonstrate it in a radiograph. The retention of a foreign body in the œsophagus may be influenced by its type ; its resiliency ; its size ; also where there is a definite spasm or organic narrowing of the œsophagus, or where there is a paralysis of the œsophagus.

In some cases it is difficult to decide by means of a screen X-ray examination whether the foreign body is in the lower end of the œsophagus or in the stomach ; but it is specially difficult in the case of the open safety-pin or the large irregular tooth-plate. Œsophagoscopy will decide where it is held up in the œsophagus, and by its aid a foreign body can be removed.

A foreign body lodging in the œsophagus may prove quickly or slowly fatal, or it may remain in the œsophagus for some years, provided its position and size allow of the passage of food. A small sharp foreign body perforating or eroding the œsophagus leads to a mediastinitis, always fatal ; its virulence depends on the size of the tear. Many other foreign bodies cause death through suppuration extending to the trachea and leading to asphyxia. Round the foreign body which lies quiescent in the œsophagus there is a compensatory thickening— an attempt to protect the œsophagus. If sooner or later the foreign body is not removed, a fatal result will ensue.

If there are urgent symptoms, such as inability to swallow, following the history of swallowing a foreign body, an immediate œsophagoscopy should be carried out. In most cases, however, a short delay is not dangerous. An X-ray plate should be made with a view to localization. The patient should only be given sterile water to drink for some hours before œsophagoscopy. Morphia is not contra-indicated as in broncho-scopy.

In no circumstances should there be any attempt at blind removal with a coin-catcher or umbrella probang ; nor should an attempt be made to push the foreign body into the stomach with a bougie passed blindly into the œsophagus. A hurried œsophagoscopy may prove fatal as it is so easy to tear the posterior wall of the œsophagus already in a partial spasm in the presence of a foreign body. A foreign body lodged in the œsophagus may often prove fatal more by immature attempts at removal than by its mere presence.

Section VI.

DISEASES OF THE EAR.

J. S. FRASER AND J. P. STEWART.

CHAPTER XXXII.

ANATOMY.

THE ear is divided into three parts : (I) *The external ear* ; (II) *The middle ear* ; and (III) *The inner ear (labyrinth)*. The last contains both the cochlear and the vestibular apparatus.

I. THE EXTERNAL EAR.

The external ear comprises the auricle and external acoustic meatus.

The Auricle, or **Pinna,** presents two surfaces, a lateral and a medial. The skeleton of the auricle is composed of cartilage. On the lateral surface the skin is closely adherent to the perichondrium. The auricular cartilage presents various prominences and fossæ which are shown in *Fig.* 138. The cartilage does not extend into the lobule which is composed of fatty fibrous tissue enclosed in skin. The lymphatics of the auricle drain into the parotid lymph glands in front, the external jugular lymphatic glands below, and the posterior auricular glands behind.

The External Acoustic Meatus measures about 24 mm. (one inch) from the bottom of the concha to the tympanic membrane, Its lateral (outer) third has a cartilaginous skeleton continuous with that of the auricle, while in the medial two-thirds the skeleton is bony (*Fig.* 139).

The antero-inferior part of the cartilaginous meatus is related in front to the parotid gland and mandibular joint.

Fig. 138.—Left auricle viewed from without. (1) Helix ; (2) Scapha (fossa of helix) ; (3) Antihelix : (4) Lobule : (5) Antitragus ; (6) Tragus ; (7) Cavum conchæ ; (8) Fossa triangularis (fossa of antihelix). The lymph glands connected with the auricle are shown

The skin lining the external acoustic meatus is closely adherent to the subjacent perichondrium and periosteum ; for this reason inflammatory

conditions of the region are extremely painful. The skin glands in the meatus are modified into ceruminous glands which secrete the ear wax.

The bony external meatus may be considered as having two walls : (1) *Antero-inferior*—formed by the tympanic plate (an outward growth of the annulus tympanicus) and related anteriorly to the mandibular articulation ; (2) *Postero-superior*—formed by the squamous part of the temporal bone. The walls of the meatus are related, antero-inferiorly, to the parotid gland and the mandibular joint ; superiorly, to the cranial wall and slightly to the middle cranial fossa ; posteriorly, to the petro-mastoid portion and the root of the mastoid process.

The nerves supplying the external meatus are the auriculo-temporal from the trigeminus, the auricular branch of the vagus, and a small sensory branch from the facial nerve.

The general direction of the cartilaginous meatus is backwards, upwards and medially ; that of the bony part is slightly downwards, forwards and medially. A well-marked prominence exists in the antero-inferior wall of the osseous meatus. The mobility of the cartilaginous meatus permits of the canal being straightened to a considerable extent. For this purpose the auricle must be pulled upwards, outwards and backwards. At the medial end of the external meatus there is an annular ridge of bone, to which the tympanic membrane is attached. The annular ridge is not a complete ring, being deficient above—the so-called notch of Rivinus.
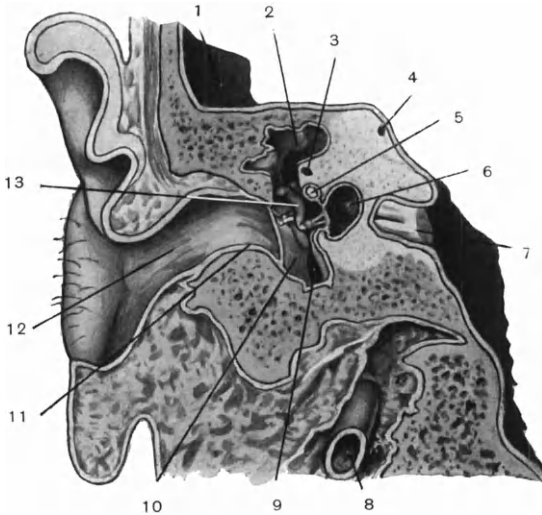
Fig. 139.—Vertical coronal section through lett ear, viewed from behind. (1) Middle cranial fossa ; (2) Attic ; (3) Lateral semicircular canal ; (4) Posterior vertical semicircular canal ; (5) Facial nerve ; (6) Vestibule ; (7) Internal acoustic meatus with nerves ; (8) Internal carotid artery ; (9) Lower part of tympanic cavity ; (10) Medial surface of drumhead ; (11) Floor of bony meatus ; (12) Junction of bony with cartilaginous meatus ; (13) Incus.

The Tympanic Membrane, or **Drumhead,** is placed between the external meatus and the middle ear. It is developed from tissue which separates the primitive auditory (Eustachian) tube and the tympanic cavity from the invagination of ectoderm which lines the external meatus. The drumhead is a layer of fibrous tissue lined on its medial aspect with the mucous membrane of the middle ear, and on its lateral aspect with the epidermis of the external acoustic meatus. The middle layer of the drumhead is composed of radiating and circular fibres, the former being firmly attached to the handle of the malleus towards the

centre, and to the annular ridge at the periphery. The tympanic membrane is placed at an acute angle to the observer, the postero-superior portion being nearer than the antero-inferior. Further, its lateral or outer surface presents a convolvulus-like curvature, with the concavity towards the observer (*see Fig.* 162, p. 268). In infants, in whom the bony portion of the external acoustic meatus is not yet developed, the tympanic membrane lies almost horizontally. This fact, combined with the small collapsed condition of the cartilaginous meatus, makes inspection of the drumhead a matter of considerable difficulty.

The fibrous layer is almost entirely absent from a small V-shaped portion of the drumhead immediately below the notch of Rivinus. This part, being less tense, is called the *pars flaccida.* The lower margins of this portion are thickened and extend from the short process of the malleus to the ends of the notch ; they are named the anterior and posterior folds of the membrane.

The tympanic membrane has a double blood-supply. The superficial vessels, which course between the epidermic and fibrous layers and appear as radiating lines in cases of catarrhal otitis media, are distributed mainly along the handle of the malleus. The deep vessels lie between the fibrous and mucous-membrane layers of the drumhead.

II. THE MIDDLE EAR.

The middle ear is a narrow, cleft-like space in the temporal bone. Anteriorly it communicates with the nasopharynx by means of a passage called the auditory (Eustachian) tube. The part of the space that lies above the level of the tympanic membrane is called the epitympanic recess (attic). Posteriorly the recess communicates by means of an opening, called the aditus, with the tympanic antrum, and through that with the mastoid air-cells. For convenience, the term ' middle ear ' is sometimes applied to the tympanic cavity.

The middle ear cleft (*Fig.* 140), which includes the auditory (Eustachian) tube, tympanic cavity, attic, aditus, antrum, and air-cells, is developed from the first visceral pouch of the embryo. It is an air-con'aining space formed by the upward and backward growth into the temporal bone of a hollow bud of mucosa from the nasopharynx.

Fig. 140.—Corrosion cast of left middle ear cleft (after Bezold). (1) Opening of auditory (Eustachian) tube in nasopharynx ; (2) Isthmus ; (3) Drumhead and tympanic cavity ; (4) Zygomatic air-cells ; (5) Posterior group of air-cells ; (6) Cells in tip of mastoid process ; (7) Air-cells in floor of tympanum.

In early fœtal life this hollow bud barely reaches the tympanic membrane, while the upper and posterior portions of the cleft are still filled with fœtal connective tissue. Later on, the bud of mucous membrane expands backwards so as to line the tympanic cavity, aditus, tympanic antrum and mastoid air-cells. During this process the tympanic ossicles and the chorda tympani nerve, to be mentioned later, receive a covering

of mucosa. It will thus be seen that the formation of the middle ear cleft is comparable in its development with that of the maxillary and frontal sinuses. In the same way the pathology of the middle ear cleft corresponds to that of the paranasal sinuses.

The Auditory (Eustachian) Tube, which is funnel-shaped and about 35 mm. (one inch and a half) in length, runs upwards, laterally, and backwards from its anterior and lower opening in the lateral wall of the nasopharynx, just behind the posterior end of the inferior concha or turbinal (*see Fig.* 9, p. 9). The close anatomical relationship of the tube to the nose and pharynx makes it liable to participate in catarrhal affections of those regions, especially in infants, in whom the tube is shorter, wider,

Fig. 141. — Vertical coronal section through right Eustachian tube as seen from the front. (1) Petrous bone; (2) Cartilage of the tube; (3) Mucous glands; (4) Levator palati muscle; (5) Detached and semidetached portions of cartilage; (6) Fatty and fibrous tissue; (7) Lumen of the tube; (8) Tensor palati (dilator tubæ) muscle.

and more horizontal than in adults. The tube has two parts : an anterior or cartilaginous which forms two-thirds of its length, and a posterior or bony portion. The narrowest part, or isthmus, is situated at the point where the two portions meet. The upper and medial walls of the anterior portion of the tube are formed by a plate of cartilage which appears hook-like in vertical coronal sections (*Fig.* 141). The lateral wall of the tube is membranous. In the resting state the lateral and medial walls lie in apposition. The fibres of origin of the dilator tubæ (tensor palati) muscle are attached to the lateral or membranous wall of the tube in such a way that, when this muscle contracts during the act of swallowing, the tube is opened and equality of air-pressure on both sides of the tympanic membrane is maintained.

The bony portion of the tube should be regarded as the anterior part of the tympanic cavity. It lies between the internal carotid artery which is situated on its medial, and the mandibular joint, on its lateral, side. The tensor tympani muscle lies in a bony canal above it. On vertical coronal section the tube presents an almost quadrilateral lumen, as shown in *Fig.* 157, p. 267. Eustachian curettes should be modelled accordingly.

The auditory tube is lined with mucous membrane covered with ciliated columnar epithelium. The submucous tissue of the cartilaginous part contains numerous mucous glands which open into the lumen. Adenoid tissue is also present in the pharyngeal portion, and constitutes the 'tubal tonsil'.

The Tympanic Cavity measures about 15 mm. (half an inch) from above downwards and from behind forwards, but it is very narrow from side to side (*see Fig.* 139). It is wider above, in the region of the attic, than below, and is deeper behind than in front. It is usually described as
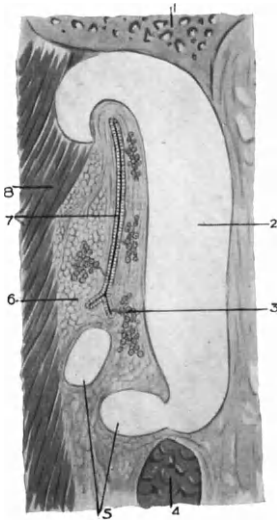
THE MIDDLE EAR 259

consisting of two parts : the tympanic cavity proper, which lies on the medial side of the tympanic membrane, and the epitympanic recess, or attic, above the level of the drumhead. A small narrow portion of the cavity, lying below the level of the drumhead, was formerly known as the hypo-tympanic cavity, or cellar.

The tympanic cavity may be described as a six-sided box. The roof of the box, which is often very thin (*see Fig.* 162), is formed by the tegmen tympani, a plate of bone which passes laterally from the petrous to articulate, and later fuse, with the squama. Above the roof lies the dura mater of the middle fossa of the skull with the temporal lobe of the brain (*Fig.* 142).
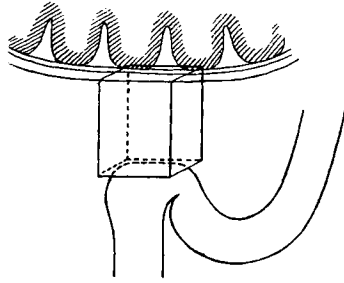
Fig. 142.—Diagram showing relations of roof and floor of left tympanic cavity. Above lie the dura mater and temporal lobe of the brain. Below is the bulb of the internal jugular vein.

The floor of the box separates the cavity from the bulb of the internal jugular vein and the carotid artery (*Fig.* 142). Here again the bony partition may be exceedingly thin. In front, the tympanic floor slopes upwards into the anterior wall, which has two openings ; the lower one is the tympanic orifice of the auditory (Eustachian) tube, while above this lies the canal for the tensor tympani muscle (*Fig.* 143).

Fig. 143.—Diagram showing anatomical relations of anterior and posterior walls of left tympanum. To the left are seen the openings for the auditory (Eustachian) tube and, above this, for the tensor tympani tendon. To the right is seen the opening of the aditus, leading to the antrum and mastoid cells.

The posterior wall, in its upper part, shows a somewhat triangular opening—the aditus, which connects the epitympanic recess (attic) with the tympanic antrum (*Fig.* 143). Just below this opening on the posterior wall there is a bony projection (pyramid) which gives exit to the tendon of the stapedius muscle.

The descending part of the facial nerve courses downwards in close relation to the posterior wall. On the medial side of the pyramid and bony covering of the facial nerve there is a recess named the sinus tympani, which lies in close relation to the medial or labyrinthine wall of the tympanum and the ampulla of the posterior semicircular canal.
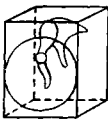
Fig. 144.—The lateral wall of the left tympanum is shown diagrammatically, with the drumhead and lateral wall of the attic.
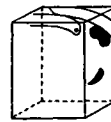
Fig. 145.—Medial wall of left tympanum, showing niche of the fenestra vestibuli (oval window) with the facial nerve above it ; below and to the right is seen the niche of the fenestra cochleæ (round window) ; above and to the left there lies the processus cochleariformis, from the apex of which the tendon of the tensor tympani emerges

The sinus tympani corresponds to the tympanic bulla of lower mammals.

The lateral wall of the tympanic cavity is formed mainly by the drumhead (*Fig.* 144). Above this, however, there is the lateral wall of the attic, formed by the horizontal part of the squama (*see Fig.* 139). The

Fig. 146.—Medial aspect of left tympanum and auditory tube. (1) Internal carotid artery; (2) Middle fossa. (3) Auditory (Eustachian) tube—just above this lies the tensor tympani muscle; (4) Canal for facial nerve; (5) Arcuate eminence; (6) Prominence of lateral semicircular canal; (7) Tympanic antrum (mastoid antrum); (8) Mastoid air-cells; (9) Fenestra cochleæ (foramen rotundum); (10) Annulus tympanicus; (11) Jugular bulb; (12) Internal carotid artery; (13) Pharyngeal opening of auditory (Eustachian) tube.

medial wall of the tympanum is a party-wall, i.e., it is also the lateral wall of the internal ear or labyrinth. The medial tympanic wall shows two openings (*Figs.* 145, 146); postero-superiorly lies the fenestra vestibuli (oval window), while below this there is the niche leading to the fenestra cochleæ (round window). Infection may pass from the tympanum to the labyrinth through the oval or round windows, or through the bony prominence of the lateral semicircular canal to be mentioned later. In front of and between these fenestræ lies the promontory—the bony covering of the basal coil of the cochlea. Above the fenestra vestibuli runs the horizontal portion of the facial nerve enclosed in a thin covering of bone. On the extreme anterior and superior part of the medial wall there is a hollow bony process (processus cochleariformis) which contains the tendon of the tensor tympani muscle.

The upper part of the tympanic cavity (attic) is the widest portion. It is divided into two sections (lateral and medial) by the head of the malleus, the body of the incus, and the superior ligament.

The tympanic aditus (*iter ad antrum*) is usually triangular on vertical-coronal section, and is the opening from the epitympanic recess into the antrum. On the medial wall and floor of the aditus is situated the white prominence produced by the bony wall of the lateral semicircular canal (*Fig.* 146). The floor of the aditus is higher than that of the tympanic
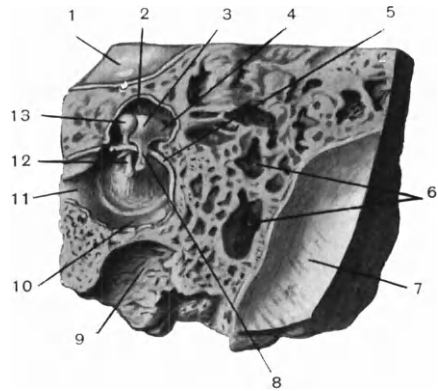
Fig. 147.—Lateral aspect of right tympanic cavity and adjacent parts. (1) Middle fossa; (2) Attic; (3) Body of incus; (4) Short process of incus; (5) Chorda tympani nerve; (6) Mastoid air-cells; (7) Groove for lateral (sigmoid) sinus; (8) Long process of incus; (9) Jugular bulb; (10) Hypotympanic cavity; (11) Auditory (Eustachian) tube; (12) Handle of malleus attached to tympanic membrane; (13) Head of malleus.

antrum. Strictly speaking, the tympanic cavity contains only air as
the three ossicles (malleus, incus, and stapes), the two muscles (the tensor
tympani and stapedius), and the chorda tympani nerve are covered by
the lining membrane and therefore lie outside the cavity—cf. the intestinal
tract and the peritoneal cavity.

Tympanic Ossicles.—The malleus consists of a head, neck, short
process, and handle. The handle is firmly attached to the drumhead
(*Fig.* 147). The incus is shaped like a premolar tooth, and consists of a
body, which articulates with the head of the malleus, a short crus fixed
to the floor of the aditus, and a long crus which descends into the main
portion of the tympanic cavity to articulate with the head of the stapes.
The stapes itself closely resembles the stirrup from which it takes its
name. It is made up of a head, neck, an anterior and posterior crus,
and a footplate. An annular ligament joins the footplate to the margins
of the oval window.

Tympanic Muscles.—The tensor tympani arises outside the tympanic
cavity, and its tendon, after leaving the apex of the processus cochleari-
formis, passes laterally at right angles across the tympanic cavity to be
attached to the handle of the malleus. The muscle is supplied by the
motor division of the trigeminus, through the otic ganglion. Its action
is to draw inwards the tympanic membrane and ossicular chain and,
consequently, to raise the intralabyrinthine pressure. The tendon of
the stapedius muscle, after emerging from the pyramid, is inserted into
the neck of the stapes. The muscle is supplied by the 7th nerve,
and, when it contracts, tilts outwards the anterior end of the stapedial
footplate and lowers the intralabyrinthine pressure. Contraction of the
tensor tympani interferes with the hearing of low tones, whereas con
traction of its antagonist, the stapedius, tends to improve the hearing.
When an effort is made to hear, it is probably the stapedius that is
brought into play.

Tympanic Ligaments.—The anterior and posterior ligaments of the
malleus surround the neck of that ossicle, and together form the axis
ligament which is attached anteriorly and posteriorly to the ends of the
notch of Rivinus. From the head of the malleus and body of the incus
a double layer of mucosa passes upwards to the roof of the tympanic
cavity (superior ligament). The movements of the malleus and incus
take place through an axis which passes through the neck of the malleus
and body and short crus of the incus. When the portions of the ossicles
situated below this axis move medially, the upper portions move laterally,
and vice versa.

Vessels and Nerves of the Tympanic Cavity.—The tympanic cavity
is richly supplied by branches from adjacent arteries. The veins of the
tympanic cavity enter the pterygoid plexus, the middle meningeal veins,
the jugular bulb, the superior petrosal sinus and carotid venous plexus.
The lymphatics drain into the retropharyngeal and parotid lymph glands.
The sensory nerve -supply is in the form of a plexus which lies on the
medial wall of the tympanum, and is formed by the tympanic branch
of the glossopharyngeal (Jacobson's nerve), a branch from the geniculate
ganglion on the facial, the small deep petrosal from the carotid plexus

and the small superficial petrosal to the otic ganglion. The chorda tympani nerve leaves the descending part of the facial nerve and enters the tympanic cavity through the tympanic aperture of the canaliculus chordæ. It traverses the cavity from behind forwards enclosed in a fold of mucous membrane, passing between the handle of the malleus and the long crus of the incus, and leaves the cavity through the medial end of the petrotympanic fissure to join the lingual nerve in the infra-temporal fossa.

Fig. 148.—Lateral aspect of left temporal bone. (1) Supra-meatal spine; (2) Masto-squamosal suture; (3) Supra-mastoid crest; (4) Mastoid foramen (for emissary vein); (5) Fossa mastoidea (surface marking for tympanic antrum); (6) Mastoid notch for digastric muscle; (7) Site of suture between squama and mastoid; (8) Tip of mastoid (*Note*: Dotted lines joining 1, 8 and 3 mark the triangle for operation on the mastoid); (9) External acoustic meatus; (10) Anterior wall of bony meatus; (11) Styloid process; (12) Vaginal processus of sty-loid; (13) Petro-tympanic fissure (Glaserian fissure); (14) Mandibular fossa. (Macewen's triangle—a guide to the position of the antrum—is outlined in white.)

The *facial nerve* runs in three different directions during its course within the temporal bone. At first it passes laterally in the internal auditory meatus, and then curves slightly upwards over the labyrinth (*see Fig.* 160, p. 267) until it comes to the anterior part of the medial wall of the tympanum near its roof. Here it bends backwards at a right angle and passes almost horizontally immediately above the oval window. When it reaches the aditus it turns downwards and continues vertically (*see Fig.* 164) until it emerges from the stylomastoid foramen.

The **Mastoid Temporal Bone** lies below and behind the squama, and behind
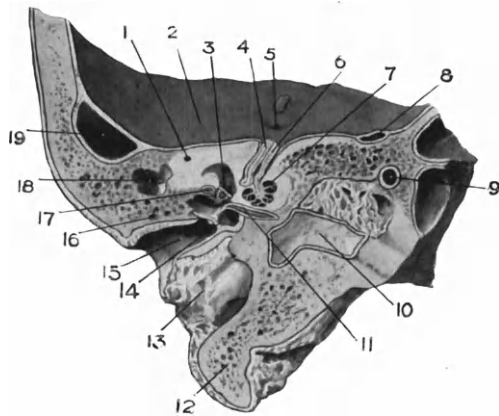
Fig. 149.—Horizontal section through right temporal bone, viewed from above. (1) Posterior vertical canal; (2) Posterior fossa of skull; (3) Vestibule; (4) Vestibular nerve; (5) Cranial opening of perilymphatic aqueduct; (6) Cochlear nerve; (7) Cochlea; (8) Inferior petrosal sinus; (9) Internal carotid artery; (10) Dura mater of middle cranial fossa; (11) Tensor tympani; (12) Zygoma; (13) Meniscus of lower-jaw joint; (14) Inner surface of tympanic membrane; (15) External acoustic meatus; (16) Air-cells between antrum and meatus (border cells); (17) Facial nerve; (18) Floor of tympanic antrum; (19) Sigmoid sinus.

and lateral to the petrous. From its lower part in the adult there juts downwards the mastoid process (*Fig.* 148). This process is absent at birth, and is small in early childhood. The mastoid temporal may consist almost entirely of air-cells with thin bony walls (cellular or pneumatic mastoid) (*see Fig.* 164, p. 268), or it may be composed mainly of sclerotic or diploëtic bone (acellular or dense mastoid) as in *Fig.* 149. The tympanic antrum is always present from birth onwards. Cheatle pointed out that in the infant, in addition to the tympanic antrum, there are present only a few air-cells, which are situated in the lateral wall
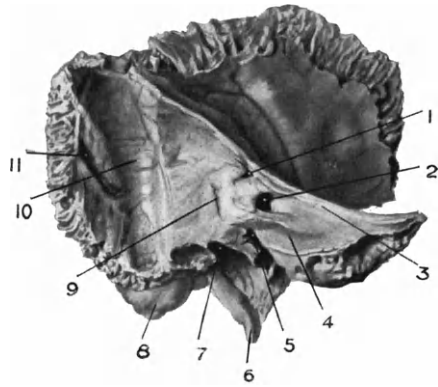
Fig. 150.—Posterior aspect of left temporal bone. (1) Fossa subarcuata; (2) Internal acoustic meatus; (3) Groove for superior petrosal sinus; (4) Groove for inferior petrosal sinus; (5) Canaliculus cochleæ (cranial opening of perilymphatic aqueduct); (6) Processus styloideus; (7) Fossa jugularis (jugular bulb); (8) Tip of mastoid process; (9) Cranial opening of aqueduct of vestibule; (10) Groove for transverse sinus; (11) Mastoid foramen (for mastoid emissary vein).
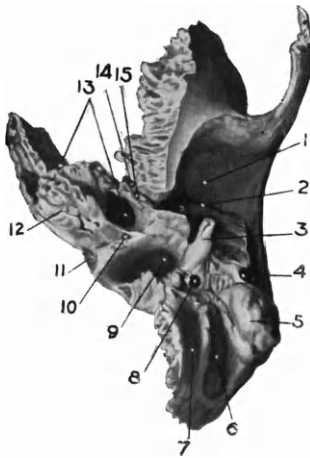
Fig. 151.—Interior aspect of left temporal bone. (1) Fossa mandibularis; (2) Fissura petrotympanica (Glaserian fissure); (3) Processus styloideus; (4) Meatus acusticus externus; (5) Processus mastoideus; (6) Incisura mastoidea (digastric groove); (7) Sulcus arteriæ occipitalis (groove for occipital artery); (8) Foramen stylomastoideum; (9) Fossa jugularis; (10) Canaliculus tympanicus (opening for Jacobson's nerve); (11) Apertura externa canaliculi cochleæ (cranial opening of perilymph aqueduct); (12) Area for attachment of pharyngeal basilar fascia; (13) Foramen carotidum; (14) Canal for tensor tympani; (15) Auditory (Eustachian) tube.

of the antral cavity. In the great majority of cases (80 per cent) the mastoid process becomes hollowed out by air-cells, which spread outwards, backwards and downwards from the antrum. In the remaining 20 per cent of cases, however, the normal pneumatization fails to occur, so that the mastoid process remains dense or acellular—the so-called 'persistent infantile' type. Wittmaack has stated that the dense type of mastoid is really a pathological one, and is due to infantile otitis media which interferes with the normal absorption of the mastoid diploë and the consequent pneumatization of the bone. Albrecht, however, disagrees and holds that pneumatization depends on the energy of the invading epithelium and the resistance of the surrounding tissue quite apart from the presence or absence of otitis media. As a rule in light and soft-boned skulls the air-cells of the process are numerous and well developed, while in thicker and harder skulls the cells are small and scanty.

In the infant the stylomastoid foramen lies almost on the surface, and for this reason it is advisable not to prolong the incision for the mastoid operation unduly in a downward direction, as otherwise the facial nerve may be cut just after it emerges from the foramen Futher, in the infant, the antrum lies at a higher level than in the adult and is very superficial, being covered in only by a thin lamella of bone which descends from the lower portion of the squamous temporal portion. Later on, as the mastoid process develops, the antrum comes to occupy a somewhat lower level. The roof of the tympanic antrum is merely the continuation backward of the tegmen tympani. The floor and medial wall of the antrum are formed by the petromastoid bone.

On the medial wall of the tympanic antrum there is a series of small veins—the remains of an important fœtal vein—which pass through the fossa subarcuata (*Fig.* 150), beneath the dome of the superior canal, to reach the posterior surface of the petrous pyramid, and there to open into the superior petrosal sinus. Infection may pass along this route and give rise to meningitis.

The air-cells connected with the middle ear cleft vary considerably in size and number in different persons. They are all lined by flattened epithelium and communicate with the antrum, aditus or tympanum. The mastoid cells form two groups—the squamo-mastoid and the petro-mastoid.

The first group includes the cells in the anterior, lateral and inferior parts of the process, the latter those in the posterior, medial and superior portions. The antrum itself is formed from both groups and sometimes shows a ridge indicating the line of division. The air-cells may extend in various directions : (1) Those constantly present are the cells in the lateral wall of the antrum, which, as has been said already, may come to occupy the whole lateral portion of the mastoid process and reach the tip, where a large cell is often present. Some of these air-cells usually extend into the posterior wall of the bony meatus in its upper part, forming the so-called 'border' air-cells (*see Fig.* 149, 16). In cases of middle ear suppuration inflammation in these cells may lead to sagging downwards of the lining membrane of the external meatus at its medial and upper part. (2) Occasionally air-cells extend into the posterior root of the zygoma and upwards into the squama (*see Fig.* 140). Infection of these cells may give rise to the 'zygomatic' type of mastoiditis with swelling above and in front of the auricle. The above two groups belong to the squamo-mastoid portion. (3) Cells may extend medially, to surround the posterior vertical semicircular canal. These cells have been named by Neumann the epibulbar or sublaby-rinthine cells. (4) Cells may reach backwards to the dense bone which forms the wall of the sigmoid groove, and may extend superficial to the sinus as far as the occipital bone (marginal cells). (5) Air-cells may extend upwards and backwards superficial to the upper knee of the sigmoid sinus—the so-called 'posterior superior' or 'petrosal-angle' cells. Groups (3), (4) and (5) belong to the petro-mastoid division. (6) From the tubal portion of the tympanic cavity air-cells may extend

into the surrounding bone and reach almost to the apex of the petrous pyramid.

The inferior aspect of the temporal bone is shown in *Fig.* 151.

III. THE INTERNAL EAR.

The internal ear consists of a membranous labyrinth (*Fig.* 155) contained within an osseous labyrinth (*Figs.* 153, 154). The membranous labyrinth is filled with fluid called endolymph, and surrounded by fluid called perilymph.

In order to understand the anatomy of the labyrinth, it is necessary to study its embryology. The essential part of the inner ear is the membranous labyrinth, which is developed in the embryo from an ingrowth of cephalic ectoderm called the otic vesicle. Later the otic vesicle becomes differentiated (*Fig.* 152) into : (1) The pars superior or static labyrinth, consisting of a membranous bag called the utricle, and three
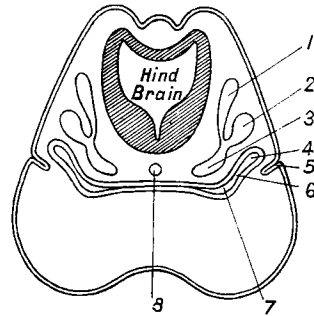
Fig. 152.—Diagram showing transverse vertical section through head of fœtus at an early stage of development, and indicating the development of the external acoustic meatus, the middle-ear cleft, and the labyrinth. (1) Primitive ductus endolymphaticus ; (2) Primitive static labyrinth (utricle and canals) ; (3) Primitive auditory labyrinth (saccule and cochlea) (4) Primitive tympanic cavity ; (5) External acoustic meatus : (6) Auditory (Eustachian) tube ; (7) Pharynx : (8) Notochord.
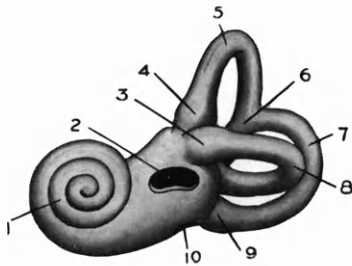
Fig. 153.—Bony labyrinth of left side, viewed from without. (1) Bony cochlea ; (2) Fenestra vestibuli (oval window) ; (3) Ampulla of lateral (horizontal) semicircular canal ; (4) Ampulla of superior vertical canal ; (5) Convexity of superior canal ; (6) Crus commune ; (7) Convexity of posterior vertical canal : (8) Convexity of lateral canal ; (9) Ampulla of posterior vertical canal ; (10) Fenestra cochleæ (round window).
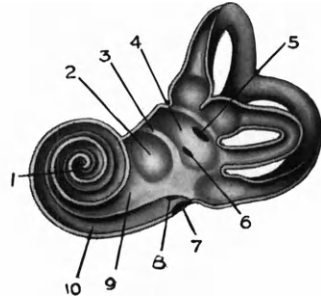
Fig. 154.—Left bony labyrinth opened up and viewed from without. (1) Helicotrema ; (2) Recessus sphericus for saccule ; (3) Crista vestibuli : (4) Recessus ellipticus for utricle ; (5) Opening of crus commune into vestibule ; (6) Opening for endolymphatic aqueduct ; (7) Fenestra cochleæ (round window) ; (8) Cochlear opening of perilymphatic aqueduct ; (9) Area of communication between perilymph space of vestibule and scala vestibuli of cochlea ; (10) Scala tympani of cochlea. (*Note* : The ridge of bone between (9) and (10) is the bony spiral lamina.)

membranous semicircular ducts (canals) ; to this part is attached the vestibular nerve and its ganglion. (2) The pars inferior or auditory labyrinth, consisting of a coiled tube called the cochlear duct or membranous cochlea, which is connected with the cochlear nerve and its spiral ganglion (*see Fig.* 159). From the developmental and probably also from the functional point of view the saccule belongs to the pars

inferior or auditory labyrinth (*see* p. 285). From the standpoint of
comparative anatomy, the static labyrinth, which is present in crustacea,
and well developed in cartilaginous fishes, is considerably older than
the auditory labyrinth, which, according to Gray, first begins to appear
in the higher reptiles.

The Bony Labyrinth.—In the early
embryo the membranous labyrinth
sinks into the mesoderm and becomes
surrounded by layers of cartilage
cells called the periotic capsule.
This later on becomes converted into
dense bone in which, however, car-
tilage cells persist throughout life.
This dense cartilage bone forms the
bony labyrinth, which is embedded
in the petrous temporal (*Figs.* 149,
153). If the cartilage-bone capsule be
artificially cut out by a skilled work-
man, it will be found to consist of:
(1) The bony semicircular canals
(*Figs.* 153, 154, 163), which contain
the membranous ducts (*Fig.* 156)

Fig. 155. — Semi-diagrammatic representa-
tion of left membranous labyrinth, viewed
from without. (1) Membranous cochlea; (2)
Saccule; (3) Utricle; (4) Crus commune;
(5) Saccus endolymphaticus; (6) and (7)
Fine ducts from utricle and saccule which
join to form the endolymphatic duct; (8)
Canalis reuniens, connecting intravestibular
part of the cochlear duct with the saccule.

and open into (2) a bony chamber called the vestibule, which contains
the utricle and saccule, and communicates anteriorly with (3) the
bony cochlea (*Fig.* 154), which
encloses the membranous cochlea.
The cartilage-bone capsule is sur-
rounded by lamellar bone formed
either from the deep layer of the
mucoperiosteum of the middle ear
or by the osteogenetic layer of the
dura mater. The interior of the
osseous labyrinth is lined with endos-
teum (*Fig.* 156). In the lateral wall
of the vestibule lies the fenestra
vestibuli (oval window) which is
closed in the living by the footplate of
the stapes and the annular ligament
(*Fig.* 162). These structures separate
the air in the tympanic cavity from
the perilymph in the vestibule.
The medial or inner wall of the
vestibule is directed towards the
internal acoustic meatus and shows
two hollows—the recessus sphericus

Fig. 156.—Vertical section through horizontal
canal. (1) Prominence of bony semicircular
canal on medial wall of aditus; (2) Endolym-
phatic space of membranous canal; (3) Peri-
lymphatic space which is lined by endosteum.

for the saccule, and the recessus ellipticus for the utricle (*Fig.* 154).
Between these two there is the small opening of the aqueduct of the
vestibule which transmits the ductus endolymphaticus. The posterior,
superior, and inferior walls of the vestibule show the five openings of
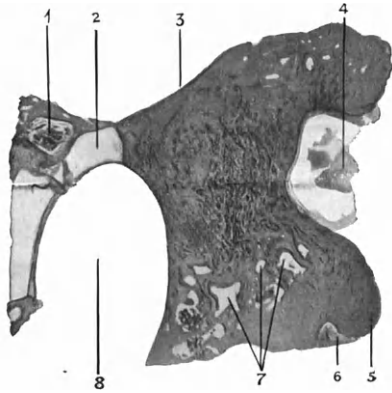
Fig. 157.*—Vertical coronal section through right ear in front of cochlea. (1) Tensor tympani; (2) Auditory (Eustachian) tube; (3) Floor of middle cranial fossa; (4) Eighth nerve in the internal meatus; (5) Posterior surface of petrous bone; (6) Glossopharyngeal nerve and opening of aqueduct of cochlea; (7) Marrow spaces; (8) Carotid canal.
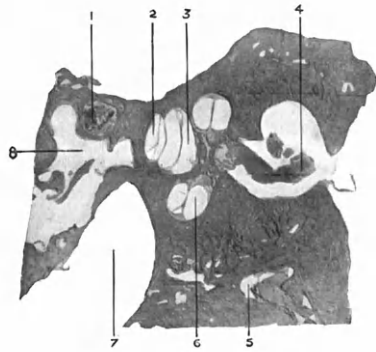
Fig. 158.—Vertical coronal section through right ear (slightly posterior to Fig. 157). (1) Tensor tympani; (2) Apical coil of cochlea; (3) Middle coil; (4) Cochlear nerve in internal meatus; (5) Cranial end of aqueduct of cochlea (perilymph); (6) Basal coil of cochlea; (7) Carotid canal; (8) Tubal portion of tympanic cavity.
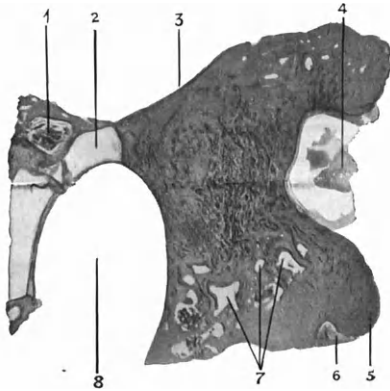
Fig. 159.—Vertical coronal section through right ear, axial section through cochlea. (1) Tensor tympani; (2) Helicotrema; (3) Canal for greater superficial petrosal nerve: (4) Modiolus; (5) Facial nerve; (6) Cochlear aqueduct; (7) Edge of cartilage-bone capsule of cochlea; (8) Carotid canal; (9) Tubal cells; (10) Tubal part of tympanic cavity.
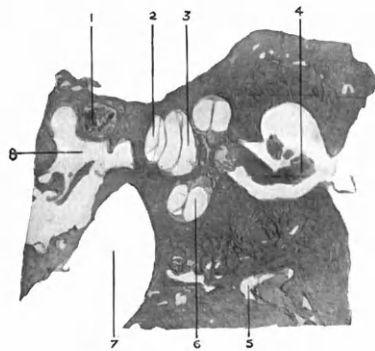
Fig. 160.—Vertical coronal section through right ear. (1) Tensor tympani; (2) Facial nerve passing above cochlea; (3) Vestibular ganglion; (4) Cochlear aqueduct; (5) Jugular bulb; (6) Air-cells in floor of tympanic cavity; (7) Tympanic cavity.

* Figs. 157-164 are made from a series of vertical coronal sections through the right ear. Fig. 157 is the most anterior, and lies just in front of the cochlea. Fig. 159 shows an axial section through the cochlea. Fig. 162 lies about the middle of the vestibule. Figs. 163 and 164 show the lateral and posterior canals.
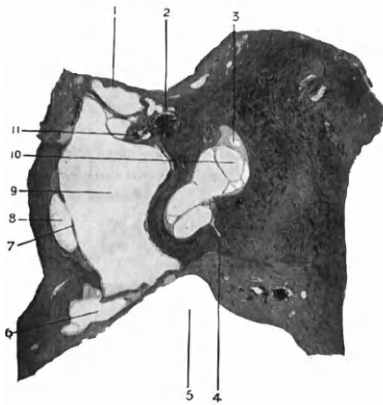
Fig. 161.—Vertical coronal section through right ear, showing vestibule. (1) Anterior part of epitympanic cavity ; (2) Facial nerve ; (3) Anterior part of utricle ; (4) Cochlear opening of perilymphatic aqueduct ; (5) Jugular bulb ; (6) Tympanic air-cells ; (7) Tympanic membrane ; (8) External meatus ; (9) Tympanic cavity ; (10) Sacculus ; (11) Tensor tympani.
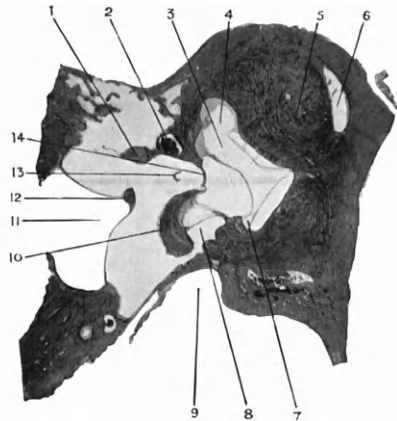
Fig. 162.—Vertical coronal section through right ear, showing vestibule. (1) Tensor tympani ; (2) Facial nerve ; (3) Utricle ; (4) Ampulla of superior canal with crista ; (5) Nucleus of labyrinth with vessels of fossa subarcuata ; (6) Superior canal ; (7) Sinus of posterior canal, with crista quarta ; (8) Niche of round window ; (9) Jugular bulb ; (10) Promontory ; (11) External meatus ; (12) Handle of malleus attached to drumhead ; (13) and (14) Head and footplate of stapes.
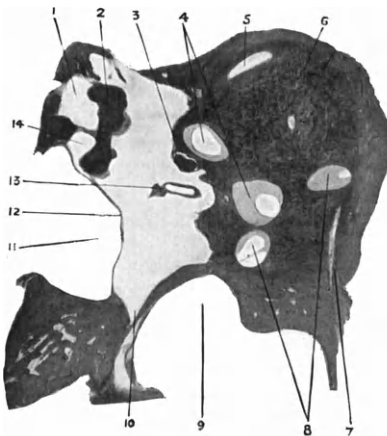
Fig. 163.—Vertical coronal section through right ear, showing canals. (1) External attic ; (2) Head of malleus ; (3) Facial nerve ; (4) Two ends of external canal ; (5) Superior canal ; (6) Remains of fossa subarcuata in labyrinth nucleus ; (7) Ductus endolymphaticus ; (8) Two ends of posterior canal ; (9) Jugular bulb ; (10) Hypotympanum ; (11) External meatus ; (12) Tympanic membrane ; (13) Stapes ; (14) Prussak's space.
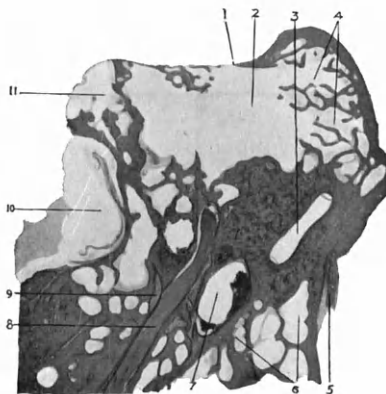
Fig. 164.—Vertical coronal section through right ear, showing posterior canal. (1) Roof of tympanic antrum ; (2) Cavity of antrum ; (3) Posterior canal ; (4) Air-cells ; (5) Saccus endolymphaticus ; (6) Air-cells ; (7) Sinus tympani ; (8) Facial nerve ; (9) Chorda tympani ; (10) External meatus ; (11) Border air-cells overhanging external meatus.

the semicircular canals. The lateral or horizontal canal has two openings, but the superior and posterior vertical canals, while they have separate openings into the vestibule at their ampullary ends, have a common opening at the smooth ends (crus commune).

The bony cochlea consists of a spiral tube wound two and a half times round its central axis or modiolus ; it resembles the shell of a snail, and lies with its base towards the internal acoustic meatus, and its apex towards the internal carotid artery (*Fig.* 159). From the central stem (modiolus) of the cochlea, which contains the cochlear nerve, a hollow bony ledge (spiral lamina) projects into each coil of the cochlea and carries the branches of the nerve. This ledge commences in the vestibule just above the fenestra cochleæ (round window) and terminates near the apex of the cochlea ; its end is called the hamulus or hook. To the edge of the bony spiral lamina the narrow angle of the membranous cochlea is attached. The outer surface of the membranous cochlea is attached to the inner wall of the bony cochlea. In this way each coil of the bony cochlea is divided into three parts : (1) The scala vestibuli above, which communicates by a wide opening with the vestibule. (2) The scala tympani below, which begins at the fenestra cochleæ (round window) (*Fig.* 162). (3) The membranous cochlea with its spiral lamina, which lies between (1) and (2) (*Fig.* 165). At the apex of the cochlea the bony spiral lamina

Fig. 165.—Horizontal section through the cochlea showing : (1) Scala vestibuli ; (2) Cochlear duct (membranous labyrinth) ; (3) Scala tympani ; (4) Cochlear nerve in internal acoustic meatus ; (5) Spiral ganglion in modiolus ; (6) Helicotrema.

ends at the hamulus, and the membranous cochlea also terminates blindly at this spot, so that the scala vestibuli and scala tympani become continuous with one another. This region is known as the helicotrema (*Figs.* 154 and 165).

The round window, which lies at the top of a deep niche, is closed by a membrane (membrana fenestræ cochleæ) which separates the air in the tympanum below from the perilymph in the scala tympani above (*Fig.* 162). Vibrations of the perilymph, set up by movement of the footplate of the stapes in the oval window, are said by some to pass up the scala vestibuli of the cochlea to the apex, and then through the helicotrema and down the scala tympani to the round window.

Membranous Labyrinth.—

1. *Static Labyrinth.*—The three membranous ducts (canals) communicate with the utricle by five openings, the superior and posterior vertical ducts having a common opening (crus commune) at their non-ampullated ends (*Fig.* 155). The three ducts lie in the three dimensions of space ;

each duct is dilated at one end into an ampulla which contains a small ridge of neuro-epithelium called the crista (*Fig.* 166). The hair-cells of the crista have long cilia which are embedded in a mass of amorphous material called the cupula. The hair-cells are supplied by a branch from the vestibular nerve. Any movement of the fluid in the ducts (canals) bends the cupula and hair-cells in one or other direction. The utricle itself shows a layer of epithelium on the superior side of its lower wall (*Fig.* 162 and *Fig.* 169); the neuro-epithelium of the saccule is placed on the antero-medial wall of its cavity at right angles to the plane of the sensory epithelium in the utricle (*Fig.* 171). In the saccule and utricle the neuro-epithelium is covered with a membrane containing otoliths into which the cilia of the hair-cells project. Both the utricle and saccule give off fine ducts which join to form the endolymphatic duct (*Fig.* 155); this ends in a dilatation called the endolymphatic sac, which lies between the layers of the dura mater on the posterior surface of the petrous pyramid.
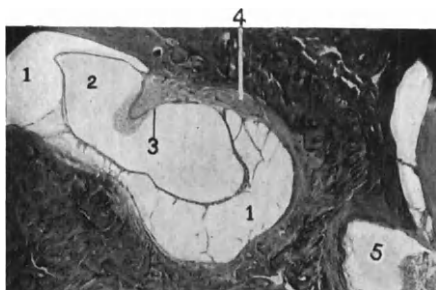
Fig. 166.—Horizontal section through lateral semicircular canal (duct). (1) Perilymphatic space ; (2) Endolymphatic space ; (3) Crista covered by cupula ; (4) Vestibular nerve to crista ; (5) Internal acoustic meatus.

2. *The Ductus Cochlearis* or *Membranous Cochlea* is a blind tube, somewhat triangular on section, coiled round a bony pillar named the modiolus. In the floor of this tube, which is wider at the apex of the modiolus than at the base, lies a small mound of neuro-epithelium called the spiral organ of Corti (*Fig.* 165). The sloping roof of the membranous cochlea is called the vestibular (Reissner's) membrane. In its lateral wall there is a layer of vascular epithelium, known as the stria vascularis, which secretes the endolymph. The narrowest part of the membranous cochlea, which lies within the vestibule of the bony labyrinth, is connected to the saccule by means of a fine duct (canalis reuniens) (*Fig.* 155).

The lymphatic system of the labyrinth is divided into two parts, endolymph and perilymph. The endolymph system ends in the saccus endolymphaticus already mentioned (*Fig.* 155). The perilymph system communicates directly with the subarachnoid space of the posterior cranial fossa by means of the narrow cochlear aqueduct, which opens out of the scala tympani of the cochlea in the region of the round window (*Figs.* 150, 154–161).

The membranous labyrinth and its capsule of cartilage bone are supplied by the internal auditory artery—a branch of the basilar—which enters at the internal acoustic meatus. The veins, on the other hand, run from the labyrinth along with the aqueducts of the vestibule and of the cochlea, and enter the petrosal sinuses. For nerve-supply, *see below.*

THE EIGHTH NERVE AND ITS CENTRAL CONNECTIONS.

The eighth or acoustic nerve consists of two parts—cochlear and vestibular—each connected with a different part of the labyrinth and with a different part of the central nervous system.

The cochlear nerve may be said to start in the hair-cells of the spiral organ of Corti, from which the fibres pass into the canal of the bony spiral lamina, and then, through the spiral ganglion, to the central canal of the modiolus. From this they pass into the internal acoustic meatus.

The vestibular nerve begins in the cristæ of the semicircular ducts (canals) and in the neuro-epithelium of the utricle. From these structures the fibres pass to the internal acoustic meatus, where they enter the vestibular ganglion. From the crista of the posterior duct and from the saccule fibres pass to both divisions of the eighth nerve.

The two divisions, cochlear and vestibular, unite and pass from the internal meatus to the side of the medulla at the lower border of the pons, where they again part company.

Central Connections of the Cochlear Nerve.—On reaching the medulla oblongata the cochlear fibres end in cochlear nuclei which lie on the restiform body (inferior cerebellar peduncle). From these nuclei fresh fibres arise which cross the median plane and, either directly or after a new relay, reach the lateral lemniscus (fillet) of the opposite side; a few fibres, however, join the lateral lemniscus of the same side. The fibres of the lateral lemniscus end in the lower auditory centres, viz., the inferior corpus quadrigeminum, which is merely a reflex centre, and the medial geniculate body. From the medial geniculate body new fibres carry the auditory impressions to the cortical centre for hearing in the superior temporal gyrus. It will thus be seen that the auditory impressions from one ear pass to both cortical centres, but mainly to that of the opposite side.

Central Connections of the Vestibular Nerve.—On reaching the medulla oblongata most of the fibres of the vestibular nerve end in vestibular nuclei in the floor of the fourth ventricle, while some of them ascend in the restiform body to the cerebellar cortex. From the vestibular nuclei fresh fibres arise and pass in different directions. (1) Certain fibres, constituting a vestibulo-spinal fasciculus, pass downwards to end round motor cells in the anterior horn of the spinal medulla; this fact explains part of the motor disturbances and alterations of muscle tonus associated with lesions of the vestibular apparatus. (2) Other fibres enter the medial longitudinal bundle and end in the nuclei of certain cerebral nerves. The most important of the connections thus established are: (*a*) With the vagus nuclei, by which the vomiting, dyspnœa and circulatory disturbances accompanying vestibular vertigo are accounted for. (*b*) With the oculomotor, trochlear and abducens nuclei, by which the occurrence of nystagmus in vestibular affections is explained. (*c*) With the nucleus of the accessory nerve which is concerned with movements of the head.

The cerebellum is the central organ for the preservation of equilibrium and co-ordination of movements. (Elliot Smith regards the cerebellum

as an overgrown part of the vestibular nucleus.)   Reflex impulses from the vestibular apparatus to the motor centres in the spinal medulla (cord) pass through the vestibular nerves to the vestibular nuclei, and thence to the cerebellar cortex.   From the cerebellar cortex, impulses pass to the nucleus dentatus, and from this they are carried by the brachium conjunctivum to the red nucleus of the opposite side ;   the rubrospinal fasciculus arises in the red nucleus, crosses the middle line, and runs downwards to end round motor cells in the spinal medulla.   Thus each cerebellar hemisphere is indirectly connected with motor cells of the same half of the spinal medulla.

Vertigo is a cerebral symptom.   The connection of the cerebellum with the cerebrum takes place through the brachium conjunctivum (superior cerebellar peduncle), many of whose fibres end in the thalamus whence impulses are carried to the cerebral cortex.

CHAPTER XXXIII.

PHYSIOLOGY AND FUNCTIONAL EXAMINATION OF THE EAR.

FOR convenience, the consideration of the physiology of the auditory and vestibular apparatus in this chapter is followed immediately by an account of the methods employed in their functional examination. From the clinical point of view, however, after the history of the patient's case has been ascertained, the surgeon proceeds to the otoscopic examination of the ear before carrying out the functional tests.

PHYSIOLOGY OF THE AUDITORY APPARATUS.

Sound-waves consist of vibrations of the air—that is, of alternate phases of condensation and rarefaction. The problem solved in the ear is the conversion of vibrations of the air into vibrations of fluid.

The auricle serves to collect sound-waves to some extent, but, as it is almost completely immobile in the human subject, this function is not of so great importance as in animals.

The auditory (Eustachian) tube acts as a ventilating shaft for the middle ear and, as it is opened up during each act of swallowing, it maintains the air-pressure in the tympanum at the same pressure as that in the external acoustic meatus. Rankin holds that, especially in high flying and in rapid aeroplane descents, immediate equalization of pressure on both sides of the drumhead is necessary. If Eustachian obstruction be present, the drumhead may be invaginated or even ruptured in a rapid descent, and the aviator may suffer from earache, deafness, nausea and vertigo.

Conduction of Sound through the Middle Ear.—According to the usually accepted theory, sound-waves strike the drum membrane and set it in motion. The vibration of the drumhead is conveyed through the malleus and incus to the stapes. The malleus and incus together form a bent lever, the long arm of which is represented by the handle of the malleus and the short arm by the long process of the incus. The leverage has a ratio of 3 to 1. The area of the drum membrane is about twenty times that of the footplate of the stapes. This gives a total increase of effective pressure of 60 to 1—an increase which is transmitted by the stapes to the fluid of the labyrinth. Wrightson and Keith believe that the tensor tympani and the stapedius muscles act in opposition to each other, and constitute an elastic balance which tends to bring the ossicles back into a position of rest.

Many observers, on the other hand. believe that the vibrations of the

18

air in the external meatus are transmitted by the drumhead to the air in the tympanic cavity, and thus reach the membrane of the round window or the promontory and set up vibrations of the fluid in the cochlea. In favour of this view it may be stated that some patients with a large perforation of the drumhead, and even some of those with no tympanic membrane, malleus or incus—i.e., cases in which the radical mastoid operation has been performed—can hear a whisper at a distance of six or eight feet. According to this view, the function of the tympanic ossicles and muscles is to regulate the fluid-pressure within the labyrinth so as to produce the best possible condition for hearing.

G. Alexander holds that differentiation must be made between ossiculo-cochlear and aero-cochlear conduction of sound. The former leads from the drumhead through the chain of ossicles to the oval window and is concerned in the hearing of low tones (up to 90 double vibrations per second). The latter (aero-cochlear) leads from the drumhead through the air in the tympanum to the round window and enables us to hear the higher tones.

Reception of Sound by the Labyrinth.—There are two theories of hearing, each of which has been modified more or less by its various adherents. The first is known as the 'piano' or 'resonance' theory, or the 'theory of peripheral analysis', and is usually associated with the name of Helmholtz. The second has been called the 'telephone' theory, or 'theory of central analysis'.

Resonance Theory.—If a tone is sung near an open piano, the string of the piano which is attuned to that tone immediately responds. According to the resonance theory the basilar membrane corresponds to the strings of the piano. The length of the fibres of the basilar membrane increases progressively from its beginning within the vestibule above the round window to its termination at the apex of the cochlea. Gray has shown that the spiral ligament which attaches these fibres to the lateral wall of the cochlea decreases progressively as it passes from base to apex. Therefore the tension of the fibres is greatest where their length is least, i.e., at the base of the cochlea, whereas at the apex the fibres are longest and the tension least. Thus the basilar membrane corresponds very closely to the strings of a piano. Wilkinson admits that the greatest difficulties in acceptance of the resonance theory are : (1) The minuteness of the scale of the cochlea as compared with the lowness of pitch of notes to which it is capable of responding ; and (2) The extensive range of tones (nearly eleven octaves) which can be heard. In addition to the variation in length and tension of the basilar membrane from base to apex of the cochlea we have also the fact that this membrane is immersed in fluid which acts as a 'load' in the same way as the copper wire with which the bass strings of a piano are loaded. The 'loading' increases from base to apex. Wilkinson has constructed a mechanical model of the cochlea in which the shortest strings are also the lightest and tightest, whilst those that are longest are also the loosest and heaviest. He found that on applying tuning-forks of various pitch to the 'stapes' of his model he produced vibrations at points which corresponded very closely to the expected position.

According to this theory, then, high tones are heard at the basal part of the cochlea, where the membrane is narrow, and low tones at the apical part, where the membrane is broad. Gray faces the difficulty that each fibre of the basilar membrane is united with its fellows on either side and so must drag them up and down to some extent, by bringing in the principle of maximum stimulation, which he illustrates by the following simple experiment : If a blunt-pointed instrument be pressed into the tip of the finger quite gently, the sensation of pressure at a point is produced in our consciousness. If the pressure be increased we are still only conscious of feeling a single point, although the skin over a comparatively large area around the point is undergoing very considerable pressure. It is clear that a great many nerve-endings are being stimulated, and yet there is only the consciousness of stimulating one. The locality, therefore, of the stimulus is determined entirely by the point of maximum stimulation.

Telephone Theory.—The other theory is that of 'central analysis' and is associated in this country with the name of Rutherford. If one speaks into a telephone the transmitter converts sound vibrations into electrical vibrations which are carried along the wire to a receiver that reconverts them into sound vibrations. The telephone itself does not analyse at all ; the analysis takes place in the ear or brain of the listener. According to the telephone theory, all the hair-cells vibrate equally to every tone, and nerve impulses of different rates of frequency are transmitted along the auditory nerve.

There are several objections to this theory of the cochlear mechanism. In the first place, in senile or arteriosclerotic deafness there is loss of hearing for the highest tones, while the lower ones are retained. Secondly, it is not uncommon in deaf-mutes to find that small islands of hearing remain in the tone scale. Thirdly, certain observers have shown that, if a guinea-pig be subjected to a certain tone for a prolonged period, the area of the cochlea which corresponds to that tone is found to be degenerated.

The Princeton Experiment.—Wever and Bray have exposed the eighth nerve of a cat and applied electrodes—one to the nerve and the other to the neck muscles. Using an amplifying system and telephone receivers they found the electrical response in the nerve to sound waves falling on the intact ear, consisted of changes in potential whose frequency reproduced that of the original sound, and even speech and music were easily recognized. Adrian found that the electrical disturbance originated in the cochlea, and that a current flowed out through the round window. Destruction of the cochlea or the application of cocaine to the round window abolished the response. By drilling holes in the capsule of the cochlea it has been shown by Hallpike that the response for low tones is increased when the electrode is applied at the apex and that the response for high tones is markedly enhanced at the base. Continued stimulation, even for an hour, does not diminish the response. Division of one eighth nerve which, contrary to Wallerian law, results in degeneration of the cochlear ganglion peripheral to the point of section (Corti's organ remaining apparently normal), abolishes the

response on the injured side. These findings have, however, been contradicted by other workers, and it must be admitted that, as yet, the problem of the site of origin of the Wever and Bray phenomenon remains unsolved. It is generally agreed, however, that incision of the drumhead does not make any appreciable difference to the transmission of sound as long as the incudomalleal and incudostapedial articulations are intact. If these joints are interfered with, conduction is impossible for all sounds of less than 4096 double vibrations. They also pointed out that when the tensor tympani muscle is at a certain degree of contraction the conduction of tones up to 2048 double vibrations is impossible. Lastly, if the membrane of the fenestra rotunda is subjected to pressure the clearness and intensity of the sounds of all pure tones between 512 and 4096 double vibrations are increased.

Our power of localizing the direction of sounds in space depends on (1) a comparison of the intensity of the sound in the two ears (intensity factor), and (2) the fact that a sound on one's right side reaches the right ear before the left (time factor). Localization is most accurate in front, next at the back, and least accurate at the side.

FUNCTIONAL EXAMINATION OF THE AUDITORY APPARATUS.

In the great majority of cases of ear disease it is necessary to investigate the condition of the hearing and to ascertain whether deafness, if present, is due to an affection of the middle or inner ear, or of both these parts. In a number of cases, too, an examination should be made of the vestibular apparatus, as the information gained by a study of the hearing tests alone is not sufficient in itself to permit of determining the exact state of the whole labyrinth or inner ear.

The functional examination of the ear will be simplified by recalling the fact that, for clinical purposes, the auditory apparatus may be regarded as consisting of two main subdivisions, the *sound-conducting* and the *sound-perceiving* apparatus. In the former are included the external acoustic meatus and the middle ear cleft, with the tympanic ossicles and joints ; in the latter, the inner ear or labyrinth, with the auditory nerve terminations, nerve-trunk, and ganglia. Further, in the internal ear two subdivisions are recognized, the auditory labyrinth with the nerve terminations in the cochlea, and the static labyrinth with the nerve-endings of the vestibular branch in the utricle, and semicircular canals. Although these two parts are structurally continuous, each has its special function, the former concerned with audition alone, the latter serving as the peripheral organ of equilibration.

Examination of the Cochlea.—It is advisable before any treatment is adopted to make a note of the results in writing, for future reference. The tests may be carried out by the watch, the acoumeter and the voice. One ear should be tested at a time, the other being tightly closed by the patient's finger, either inserted in the meatus or pressed against the tragus. In testing the deaf ear in a case where there is a marked disparity between the hearing of the two sides, it is sometimes impossible to say whether the test sounds are heard by the deaf or by the good ear, if the

latter is closed in the ordinary way. To obviate the possibility of mistake, Bárány's noise apparatus should be used in the good ear. The instrument is worked by clockwork and is provided with an earpiece which is inserted into the meatus. When the clockwork is turned on, the resulting noise fully 'occupies the attention' of the ear (say the left) to which the apparatus is applied, and the surgeon can feel sure that any words spoken or even shouted into the other (right) ear have been heard by that ear only if they are repeated by the patient.

The results of the tests by a watch are expressed by a fraction, of which the numerator indicates the distance in inches at which the watch is heard by the patient's ear, and the denominator the mean distance at which the same watch is heard by persons with normal hearing. Accordingly, if a patient hears a watch at 12 inches which is heard at 36 inches by an individual with normal hearing, the result is expressed H (horologium) $= \frac{12}{36}$. In carrying out this test, the watch should be held at first beyond the range of audition and slowly approximated to the ear until the tick is heard ; the test should be repeated two or three times to avoid gross errors. If heard only when touching the ear, the watch is said to be heard on contact. It is important, also, to test the patient's power of hearing a watch by bone conduction. For this purpose the watch is pressed lightly on the patient's forehead and, afterwards, on his right and left mastoid processes. If a patient can hear the watch without difficulty in all these positions, nerve deafness may almost certainly be excluded. In dealing with children, it is advisable to make them close their eyes ; otherwise a lively imagination or a desire to please may vitiate the result. An acoumeter should be used when the tick of a watch is inaudible, but for ordinary clinical work the Waterbury Crown watch is usually employed.

In testing with the voice, a whisper, either low or loud, is used if it can be heard ; if, however, a whisper is not audible, recourse must be had to the speaking voice, and a low, ordinary, or loud voice is employed, according to the deafness of the individual. The patient sits with his eyes closed, to prevent lip-reading. The ear not under examination is occluded by the finger, while the ear to be tested is directed towards the examiner. The patient is asked to repeat the words he hears. If the patient cannot repeat accurately, the examiner comes nearer or raises the tone of his voice. If the patient does hear and repeats the words at once, the examiner moves farther away or employs a lower tone. In this way a record is obtained of the hearing of each ear, e.g., right ear = conversation voice at 8 feet ; left ear = whisper at 12 feet. (The hearing distance should be tested again after the use of Politzer's method of inflation or the Eustachian catheter.) Single words should be spoken, and it must be remembered that some words are harder to hear than others, vowel sounds being more readily perceived than consonants, while the consonants themselves vary, as they differ greatly in pitch. The letter r is the lowest, having, according to Oscar Wolf, only 128 vibrations per second, while the letter s is the highest, and may have over 10,000 vibrations per second. Thus, from a judicious selection of words, some inkling may be gained as to the site of the lesion in a case

of deafness, by testing with the voice alone. The following words may be suggested as suitable for hearing tests : father, window, baby, table, monday, Glasgow, sister, captain, picture, china, carpet, uncle, sofa, London, telephone, Aberdeen ; numbers, such as twenty-two, forty-six, eighty-one, ninety-nine, are somewhat easier for the patient to pick up. While the carrying out of these tests is a matter of extreme simplicity when dealing with intelligent adults, it is often impossible to obtain accurate results with nervous children. In this case it is better to ask simple questions in a low voice or a whisper—e.g., 'How old are you ?' 'What is your name ?' ' Where do you live ?'—when a rough idea may often be obtained of the acuity of hearing.

Tuning-fork Tests.—When the acuity of hearing has been approximately gauged by the methods described above, it is necessary to carry out certain tuning-fork tests. It is in this way that information is derived as to the state of the sound-conducting and sound-perceiving apparatus, and knowledge is gained as to the site of the lesion producing the deafness. A large number of these tests have been advocated by various authorities, but the impartial critic must admit that no claim to scientific accuracy can be made for any of them, although some afford considerable assistance in the clinical investigations of cases of deafness. It is sufficient for ordinary clinical work to carry out three tests, viz., Schwabach's, Weber's and Rinné's, and, in addition, to determine the perception of the upper and lower tone limits. For the first three a medium tuning-fork should be selected, such as $c^1 = 256$ double vibrations a second. The fork should be fitted with clamps to deaden the overtones when it is thrown into vibration. It is sounded by holding the stalk between the finger and thumb, and striking the prongs firmly and smartly against a resisting object, such as the edge of a table or the heel of one's shoe ; if the prongs are then approximated to the external auditory meatus and the sound is heard by the patient, the fork is said to be heard by *air-conduction* $=$ AC. In testing air-conduction the tuning-fork should be held opposite the ear in a vertical position, with the prongs downwards. When it is heard by placing the end of the stem in contact with the bone of the skull, it is described as being heard by *bone-conduction* $=$ BC.

Schwabach's Test.—This consists in comparing the duration of bone-conduction in an individual with normal hearing, and in a deaf person. It is of less value than the other tests, because the variations in time in normal individuals are considerable. The test is carried out as follows : The examiner strikes the tuning-fork and places it on the vertex in the middle line of his head (presuming that his hearing is normal) and waits until he no longer hears the fork sounding; he then transfers the fork to the patient's vertex and asks him if he hears it. If the reply is 'Yes', Schwabach is said to be lengthened. If the reply is 'No', the test must be repeated, but on this occasion the sounding-fork is first placed on the patient's vertex and, when he ceases to hear it, transferred to that of the examiner. In this way it may be found that the patient's bone-conduction is shorter than normal. Generally bone-conduction is markedly diminished in nerve deafness and is lengthened in lesions of the sound-conducting apparatus, especially in otosclerosis.

Weber's Test.—This is of service in cases of unilateral deafness. It depends on the following experiment : If a sounding tuning-fork is placed on the vertex in the middle line, it is heard equally on both sides, but if one ear is closed by the finger the sound immediately becomes much louder on that side. In this experiment the patient produces artificially a lesion of the sound-conducting apparatus, so that its application to a case of unilateral deafness is at once obvious, viz., if a sounding tuning-fork placed on the vertex is heard better on the deaf side, the patient is suffering from a lesion of the sound-conducting apparatus ; but when it is referred to the sound side, the lesion is in the sound-perceiving apparatus of the affected side.

It is important to remember that the word of the patient is often unreliable in this test. Patients are very anxious to give intelligent answers, and during Weber's test they often state that the fork is heard best in the good ear, because they think that this must necessarily be so. It is well, therefore, to ask the patient to say at once exactly what he hears, and not to stop to think about it.

Rinne's Test. — This consists in comparing the duration of bone-conduction with that of air-conduction. Rinne found that in every individual with normal hearing air-conduction is longer than bone-conduction ; this is called Rinne positive (R +). When the opposite state of affairs is found, viz., BC > AC, Rinne's test is said to be negative (R −). The test is performed as follows : Strike the tuning-fork and hold it beside the ear to be tested. Tell the patient to raise his hand when he can no longer hear it. When he gives this signal, immediately place the handle of the fork on his mastoid process and ask him if he again hears it sounding. If the answer is 'Yes', Rinne's test is negative, and the patient is suffering from a lesion of the sound-conducting apparatus. Rinne's test is positive in health and in lesions of the sound-perceiving apparatus (nerve deafness). In 'mixed middle and inner ear deafness' both air-conduction and bone-conduction are shortened, but the normal relations are reversed, bone-conduction being longer than air-conduction.

Somerville Hastings lays stress on the importance of estimating the absolute bone conduction of the patient. The observer (who presumably has normal hearing) and the patient each blocks his external auditory meatus with his finger (preferably by pressure on the tragus). A vibrating tuning-fork is then pressed on to the mastoid process of the patient and, after he has ceased to hear it, on to that of the observer until no longer heard. Hastings has never found *absolute bone conduction* increased above the normal in any single case of deafness. By means of the absolute bone conduction (A.B.C.) test it is possible to estimate the percentage of normal perceptive (cochlear) hearing retained by a patient, i.e., it is a test for the presence or absence of nerve deafness.

When these tests have been carried out, the limits of audition at either end of the scale should be tested. The lowest note which a normal individual can hear by air-conduction is produced by a fork which gives 16 double vibrations per second, but for practical purposes it is sufficient to begin the tests with a fork giving 32 double vibrations (C^1), for everyone with normal hearing can hear the sound produced by that fork,

though to some the lowest fork is not audible ; if the C^1 fork is not heard, the next in the series should be tried, i.e., C (64 d.v.s.). Perception of the lower tone limit is lost in lesions of the sound-conducting apparatus, especially in otosclerosis. The upper tone limit can be tested by the monochord. This instrument consists of a single stretched piano-wire in a metal frame. Longitudinal vibrations are produced by rubbing the wire with a piece of cotton-wool moistened with benzol. The length of the vibrating wire can be shortened by means of a movable bridge, so that tones ranging from 6000 to 25,000 double vibrations per second can be produced. The highest note audible in health is one giving 19,000 double vibrations per second. The upper tone limit (U.T.L.) is lowered in old age and in patients suffering from a lesion of the sound-perceiving apparatus.

In cases in which it is important to obtain an accurate record of the range of hearing, the Bezold-Edelmann continuous tone series of forks, pipes, and whistle may be employed, but for ordinary use the series of C forks is sufficient. The range of these forks is as follows : $C^2 = 16$ double vibrations per second ; $C^1 = 32$ d.v.s. ; C=64 d.v.s. ; c=128 d.v.s. ; $c^1 = 256$ d.v.s. ; $c^2 = 512$ d.v.s. ; $c^3 = 1024$ d.v.s. ; $c^4 = 2048$ d.v.s. ; $c^5 = 4096$ d.v.s. Above this tone the monochord is employed. The duration of the patient's hearing for each fork as compared with that of a normal person is noted—e.g., c^4 shortened ten seconds as compared with normal

Audiometer Test.—Two types of this instrument are used : (1) The electrical audiometer, and (2) The gramophone audiometer.

1. Briefly, sounds corresponding to the pitch of 64 to 8,192 double vibrations per second are emitted by a loudspeaker, and the patient sits at a measured distance from the instrument with the ear plugged which is not to be tested. The intensity of these tones is governed by a dial which is set at zero and then gradually increased until the patient makes a signal that he can hear the note. The different pitches are then tested and the results noted down on a special graph which is provided with the line of normal hearing. The various results obtained from the patient are joined by a line and the curve of hearing by air conduction defined. If a head-phone is used then of course the hearing of bone-conduction is tested (*see Figs.* 167 and 168).

2. Where a number of children require to be tested, gramophone audiometers are used. The ears are tested separately and then together by means of specially adapted head-phones. A record of easy numbers, e.g., 236, 417, 829, and so on, is played on the audiometer, and the children are instructed to write down what they hear. The loudness of the sounds is gradually diminished and the deaf child begins to make mistakes or to fail altogether to write down the numbers.

PHYSIOLOGY OF THE VESTIBULAR APPARATUS.

Historical.—Flourens was the first to show, in 1824, that division of the semicircular canals in pigeons caused active movements of the head, the eyes and, sometimes, of the whole body in the plane of the divided canal. Mach, Breuer and Crum Brown, in 1875, proved that the semi-

circular canals are the peripheral organs of a sense of rotation. Ewald
undertook further investigations and found by experiments on pigeons
that movement of the endolymph from the convexity towards the ampulla
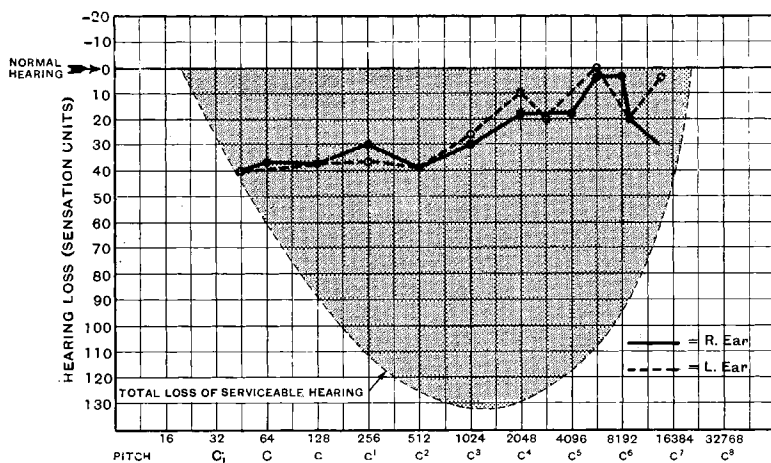
Fig. 167.—Audiograph in otosclerosis.

of the right semicircular canal causes nystagmus to the right, i.e., in the
direction opposite to the flow of endolymph ; while movement of the
endolymph in the same canal from the ampulla towards the convexity
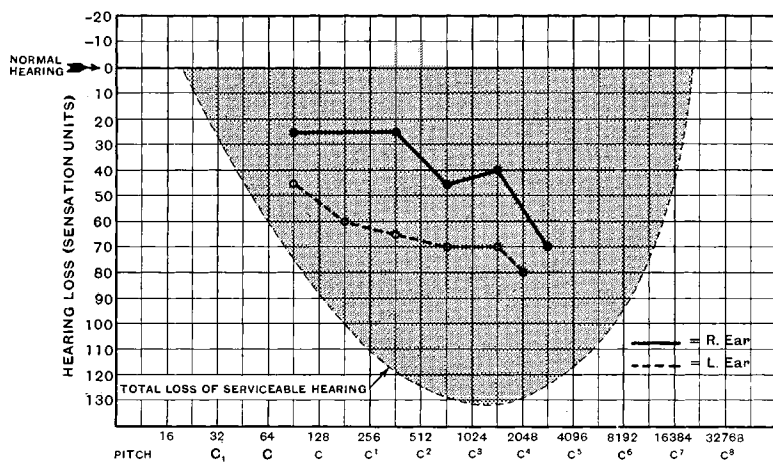
Fig. 168.—Audiograph in senile nerve deafness.

causes nystagmus to the left. In 1907 Bárány published his classical
monograph, *The Physiology and Pathology of the Semicircular Canal
Apparatus in Man, including its Functional Examination.* During recent

years, following the researches of Sherrington, much work has been carried out on the static labyrinth by Magnus, de Kleijn, Quix, Tait, McNally and others. Though much still remains to be done to elucidate the subject, an attempt has been made in the following pages to give the reader an account of the present position.

The Vestibular Apparatus.—The balance of the body is maintained by the co-operation of various organs and mechanisms, i.e.: (1) The tactile, muscular and visceral senses ; (2) The eyes ; (3) The vestibular apparatus. Of these the greatest is the vestibular apparatus.

The general function of the vestibular apparatus is to inform the individual of the movements and position of the head in space so that the necessary readjustments of the body can be made. The vestibular apparatus may be regarded as the gyroscope of the head (McNally).

Tait points out that the static labyrinth or vestibular apparatus consists of two parts : (1) The semicircular canals which are organs of kinetic or dynamic equilibrium. The semicircular canals are stimulated by rotation or by movement in a straight line, either vertically or horizontally ; the resulting reactions are movements which cease when the stimulation evoking them fails. By aid of these reactions from the semicircular canals animals turn and jump and yet maintain their balance. (2) The utricle, which is entirely an organ of static equilibrium. The utricular macula is stimulated by variations of position of the head in relation to the horizontal plane. The reflex reactions from the utricular maculæ are variations in muscle tone and therefore in attitude, and these variations persist so long as the posture of the head which gives rise to them is maintained. The utricular macula elicits slowly, and maintains a readjustment of the eyes and limbs to counteract any movement of the head so long as the new position of the head is kept up. It exerts a tonic influence on the body musculature.

When the head is suddenly moved the semicircular canals elicit a sudden counter-movement of the eyes and limbs, the new attitude assumed being maintained by the utricular maculæ and co-operative reflexes from the other sense organs of the body so long as the new position of the head is unchanged. Thus it may be said that the semicircular canals regulate equilibrium during movements of the body. The utricles regulate equilibrium in positions of the body.

The oculo-motor apparatus is intimately associated with the static labyrinth. For most purposes of course ocular movements are controlled by the cortical centres, but it is obvious that once the attention and the eyes are fixed upon any object, for instance on an opponent, the advantage should not be lost by any sudden change in position of the observer and, further, that the sudden change in position must itself supply the necessary stimulus directly to the oculo-motor centres. For this reason the static labyrinth is so 'geared up' with the oculo-motor apparatus that a sudden change of mass or angular acceleration in one direction causes a corresponding movement of the eyes in the opposite direction. In close combat, e.g., boxing or fencing, rapid changes of position are essential yet the eyes must always remain fixed upon the opponent.

The different functions of the static and kinetic labyrinths have been demonstrated very clearly as the result of centrifuging anæsthetized guinea-pigs at a very rapid rate. Subsequent microscopic examination of the labyrinth has shown that rapid centrifuging detaches the otolithic membrane of the utricle while the semicircular canals remain unimpaired. In such animals all labyrinthine reactions caused by angular or recti-linear acceleration are present as they depend on the integrity of the canals. On the other hand, all reflexes resulting from position disappear, including the tonic labyrinthine reflexes upon the limb muscles. These reflexes, therefore, depend upon the utricle.

The Static Labyrinth.—

The Utricle.—The utri-cular macula consists of a disc of nervous epi-thelium with projecting hair cells covered by a colloidal substance con-taining crystals of a lime salt (the otolithic mem-brane or lapillus), which is in intimate contact with t h e neuro-epithelium (*Fig.* 169). The stimu-lation of the macula is the pressure or pull of the otolithic membrane on the hair cells. If the head is erect the two maculæ lie below while the otolithic membranes are above and press equally on the hair cells of both maculæ (*Fig.* 170). If the head is moved laterally and kept in this position, the otolithic
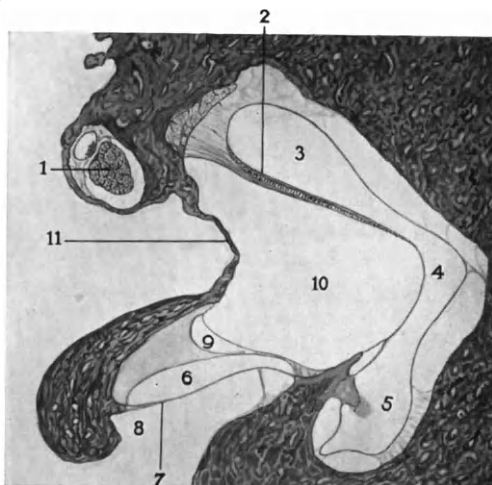
Fig. 169.—Vertical section through right vestibule (semidia-grammatic) showing position of neuro-epithelium of utricle. (1) Facial nerve in its bony canal; (2) Otolith membrane of utricle overlying the neuro-epithelium; (3) Cavity of utricle; (4) Opening of crus commune into utricle; (5) Ampulla of posterior canal with crista and cupula; (6) Scala tympani of cochlea; (7) Membrane of round window; (8) Niche of round window; (9) Intra-vestibular part of cochlea; (10) Perilym-phatic space of vestibule; (11) Footplate of stapes in oval window.

membrane presses on one side more than on the other and nervous impulses are set up which are interpreted as a definite position of the head. This stimulation continues as long as the head maintains this position. In the inverted position of the head the macula is of course situated above and the otolithic membrane lies below and pulls on the hair cells. Magnus regards the maximum stimulus as the pulling of the otolithic membrane on the macula and holds that this pulling causes an increase of tone in the extensor muscles of the limbs. Quix, on the other hand, considers that pressure of the otolithic membrane on the macula is the maximum stimulus and believes that this causes an increase of tone in the flexor muscles of the limbs. However, for practical purposes these two theories are very similar.

Magnus and de Kleijn have pointed out that a fish living in water

requires some mechanism whereby its balance may be maintained by the assistance of gravity. For this purpose the balancing apparatus must automatically control the muscles of the body. The dead fish, as is well known, turns 'belly upwards'. Werner and Maxwell, by experiments on fish, in which the otolithic membranes are large and heavy and deserve the title of 'ear stones', have proved definitely that all the reflexes of position proceed from the macula utriculi. Further, McNally finds that when the nerve to one utricle is cut, a frog, notwithstanding the nervous messages from the eyes, muscles, palms and soles, no longer sits naturally ; on a horizontal surface it leans over to the operated side.

Fig. 170.—The hands show the horizontal position of the right and left utricles in the upright position of the head. The discs lying on the hands represent the otolith membranes.

Methods of Testing the Otolithic Reactions.—The patient sits in a chair with his head erect. The presence or absence of nystagmus is noted. The vertical and horizontal pointing reactions are also observed (p. 291). The patient's head is then laid over towards his right shoulder and, after the lapse of thirty seconds to allow the reaction from the canals to subside, an examination is again made as regards nystagmus and vertical pointing. The head is then laid over towards the left shoulder and a similar examination repeated. Next the patient's head is tilted backwards and, finally, forwards, and similar observation are carried out. Past-pointing in any of these positions indicates a lesion of the utricular or otolithic apparatus. Several cases have been recorded in which a

patient suffers severely from giddiness when lying on one side, say the right, but is quite comfortable when lying on his back or on the left side.

The Saccule.—The function of the saccule has not yet been determined. Magnus and de Kleijn and also Quix have stated that the saccule is to be regarded along with the utricle as an organ of equilibration. They pointed out the similarity in structure of the saccule (*Fig.* 171) and utricle (*Fig.* 169) and believed that the saccule was concerned in the production of certain compensatory eye positions and asymmetrical labyrinthine righting reflexes. Tait and McNally, however, find that when one or both saccular otoliths are removed or when the nerves of the saccular maculæ are cut, a frog sits, crawls, jumps and swims absolutely in the normal way. They hold that while sound vibrations of more than sixteen double vibrations per second are perceived by the cochlea, i.e., hearing as we ordinarily understand it, vibrations below sixteen per second are perceived by the saccule. The saccule may thus be intermediate between the cochlea on the one hand and the semicircular canals on the other. This view is in accordance with the development of the membranous labyrinth. The cochlea and saccule belong to the pars inferior while the utricle and canals form the pars superior (*see Fig.* 152).

Research work on fishes has led H. M. Smith to come to the conclusion that the sacculus is concerned with hearing and the utricle with equilibration. In fish, vibrations are received through the water and are communicated directly through the body walls to the saccule. The hearing in fish is therefore analogous to bone conduction.

Fig. 171.—Horizontal section through the saccule; (1) Perilymphatic space; (2) Cavity of saccule (endolymphatic space); (3) Otolith membrane covering neuro-epithelium of saccule; (4) Saccular branch of the 8th nerve.

A typical fish has an internal ear with: (1) A utricle with its otolith, named the lapillus, and three semicircular canals; (2) A sacculus with a large macula on which rests its otolith, the sagitta, and another macula in a specialized area called the lagena. (This lagena is generally held to represent that part of the internal ear which, in air-breathing animals, develops into the cochlea.) Von Frisch established a conditioned reflex in certain fish. They were educated to look for food when they heard a special sound. When the semicircular canals and utricles were removed the animals still responded, but when the saccule and lagena of both sides were removed the fish did not respond. These experiments suggested that in these fish the saccule was part of the hearing mechanism. It is at least possible that in mammals also the saccule may have a similar function. This brings us back to the

old theory that the saccule was concerned in hearing noises as distin-
guished from musical sounds.

Ashcroft and Hallpike in their recent researches on the saccule of
the frog came to the conclusion that it was not possible to elicit from the
saccular branch of the eighth nerve any response to tilting or rotation
but vibration produced a marked reaction. The sacculus was probably
responsible for the hearing of bone conducted sound.

'Balance' and 'perception of sound' are associated intimately from very
early phylogenic times. That this close association still persists is
evidenced not only by the proximity of the vestibular and auditory
organs, but also by the persistent influence of sound on movement,
e.g., dancing, marching, or the inevitable 'start' that follows unexpected
noise. G. Alexander holds that the cochlear and vestibular apparatus
are combined anatomically in one organ because they both control
orientation and both respond to the movement of fluid in the inner ear.
Orientation by sound depends on the cochlea.

Righting Reflexes.—Righting reflexes are those by which an animal from
every abnormal position in space is able to restore itself to the normal
position. There are three groups of co-operating reflexes : (1) Touch,
muscular and visceral sense. Interference of balancing due to the loss
of this sense is of course demonstrated by the application of Romberg's
test in a case of locomotor ataxia. (2) The optical righting reflexes.
In man these play a very important part ; for instance, when an
aeroplane is passing through clouds the exclusion of visual impressions
makes orientation practically impossible. (3) Vestibular apparatus.
If an intact animal, e.g., a guinea-pig, is held by the pelvis in the air,
the head is always brought into the normal position no matter whether
the body is rotated to one side or the other. Labyrinthine righting
reflexes can also be demonstrated in infants who are blindfolded and
held up by the pelvis in different positions in the air. Babies in the
prone position bring the head by dorsiflexion into the normal position
of the head ; this is followed by lordosis of the vertebral column with
extension of the limbs. Rotation of the baby's head causes the body
to roll from the supine into the lateral position. (4) The zero condition,
in which all righting reflexes are suppressed, is realized if a patient with
acquired deaf-mutism due to bilateral destruction of the membranous
labyrinth is submerged in a swimming bath. As the patient gets no
sensations from the soles of his feet and as he cannot see under water
and, lastly, as his labyrinths are functionless, he may quickly drown if
care is not taken to help him out of the water.

Posture.—Magnus holds that posture is an active process resulting from
the co-operation of a great number of reflexes, many of which have
a tonic character. These tonic reflexes arise from the otolithic organ.
In order to understand what Magnus means, one has only to observe the
unnatural attitudes of tailors' dummies and dressmakers' figurines in
shop windows. A normal person with active otolithic organs would not
retain such attitudes for any length of time.

The Kinetic Labyrinth.—

The Semicircular Canals.—The semicircular canals respond to sudden

movement or acceleration of movement and they elicit sudden readjust-
ment of the eyes and limbs to counteract the movements of the head.
Most observers hold that they have no tonic effect upon the body
musculature.

Crum Brown demonstrated that while one canal was affected by, and
transmitted the sense of, rotation about one axis in one direction only,
for complete perception of rotation in any direction about any axis,
six semicircular canals were required, arranged in three pairs, each pair
having its two canals parallel (or in the same plane) and with their
ampullæ turned opposite ways. Crum Brown found that the lateral
canal of one ear was very nearly in the same plane as the lateral canal
of the other, while the superior canal of one ear was nearly parallel to
the posterior canal of the other (*Fig.* 173). Each pair would thus be
sensitive to any rotation about an axis at right angles to its plane, the
one canal being influenced by rotation in one direction, the other by
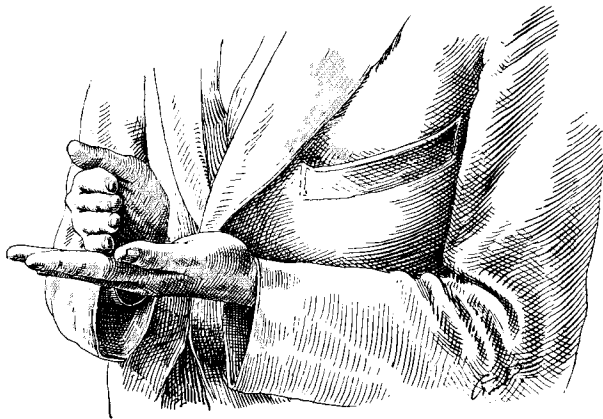
Fig. 172.—Showing the position of the horizontal and of the two vertical semicircular
canals of the left side.

rotation in the opposite direction. Recent research has shown that it
is more true to say that each canal is maximally stimulated by movement
of its contained fluid in one direction, i.e., from the smooth or non ampul-
lated end towards the ampulla.

In order to remember the position of the three canals, the following
device is useful (Bárány) (*Fig.* 172). The arms are laid against the sides
of the body and then, with the elbows bent at a right angle, the hands
are made to meet in the middle-line, palm upwards—the middle fingers
touching and enclosing an angle of 90°. The position of the forearms
and hands thus corresponds to the long axis of the right and left petrous
pyramids. With the left hand in this position the fingers of the right
hand are bent at right angles at the metacarpophalangeal joints, the right
forearm is slightly pronated, and the right hand thus bent is placed on the
left hand, so that the ulnar border of the little finger lies across the
palm of the left hand. In this position the palm of the left hand

Utricle   Utricle

Posterior

Right   Left

Smooth part   Smooth part
of canal   of canal

Anterior

Ampulla with cristæ   Ampulla with cristæ
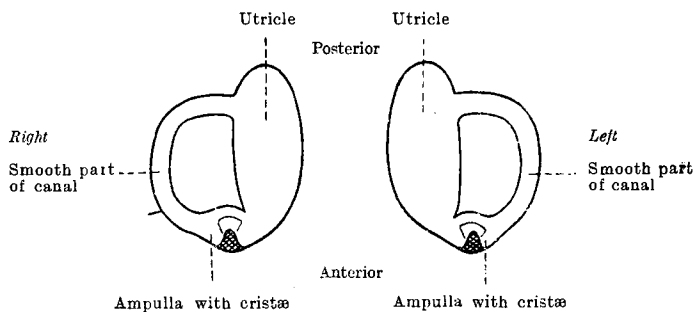
A.—Shows the right and left utricles, with the lateral (or horizontal) canals and their ampullæ containing the crests. The utricles and canals are seen from above. The patient is looking towards the bottom of the page.

Smooth part of canal

Utricle

Ampulla

Right   Left

Smooth part
of canal

Utricle

Ampulla
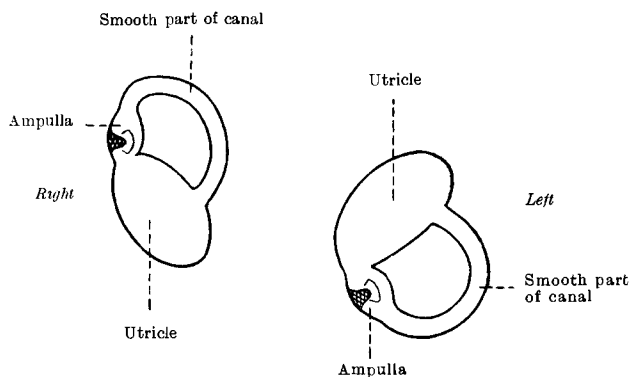
B.—Shows the utricles of the two sides, right and left, and demonstrates the fact that the superior vertical canal of the right side lies in a plane parallel to that of the posterior vertical canal of the left side. The utricles and canals are looked at from the front, the patient looking towards the reader.

Smooth part of canal

Utricle

Ampulla

Left

Right

Smooth part
of canal

Utricle

Ampulla
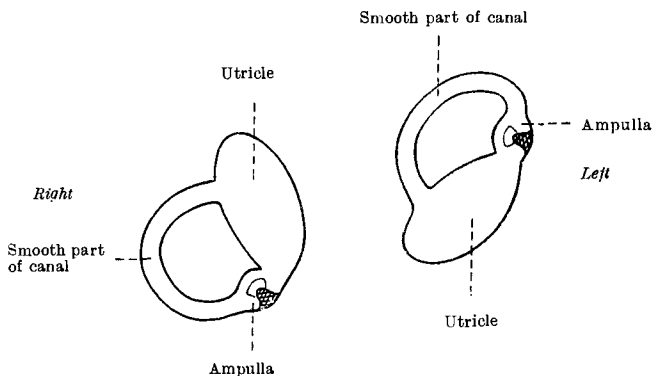
C.—Shows the utricles of the two ears, right and left, and demonstrates the fact that the superior vertical canal of the left side lies in a plane parallel to that of the posterior vertical canal of the right side. The utricles and canals are looked at from the front, the patient looking towards the reader.

Fig. 173.

represents the plane of the left horizontal (lateral) canal, the fingers of the right hand the plane of the left anterior vertical (superior) canal, and the palm of the right hand the plane of the left posterior vertical canal. The convexity of the three canals is turned towards the free borders of the hands, i.e., the horizontal outwards, the anterior vertical upwards, and the posterior vertical backwards. If the hands are now reversed and the left is superimposed on the right, the position of the three canals on the right side is obtained. (It will be noticed that while the planes of the two horizontal canals coincide, the right superior canal is on a plane parallel to that of the left posterior canal, while the right posterior canal is on a plane parallel to that of the left superior canal —*Fig.* 173). It is, of course, obvious that the planes of the canals alter with each movement of the head, e.g., if the head is bent 60° backwards the horizontal canal becomes vertical, etc.

Rotation of the body causes movement of the endolymph in one or more pairs of semicircular canals. When the endolymph current is towards the ampulla, the hairs on one side of the crista are put on the stretch, while if the current is away from the ampulla, the hairs of the opposite side are put on the stretch (*Fig.* 174). It has been shown that a current towards the ampulla in the horizontal canal produces twice as strong a reaction as a current away from the ampulla. The only possible explanation of the phenomena which are observed after vestibular stimulation is that there is movement of the endolymph, e.g., douching the ear with the head forwards produces exactly the opposite effect from douching the ear with the head backwards. It is not true, as some have held, that cold water causes a depression and hot water a stimulation of the hair-cells of the crista.

Fig. 174.—Diagram of flow of endolymph in horizontal semicircular canals in rotation test. The observer, standing above and in front of the patient, is asked to visualize what is taking place in the canals at the beginning and also at the end of the test. The patient is looking towards the bottom of the page.

Movements of the head in any given plane cause a relative movement of the fluid in the canals of that plane. A nerve impulse is transmitted to the brain and reflex adjustment of the eyes and limbs is brought about. Reactional movements of the head, trunk and limbs following

19

stimulation of the semicircular canals are always in the direction of the flow of the endolymph. This is a protective reflex. For instance, if a person is falling backwards, e.g., slipping on a banana skin, the accelerated rotatory movement is in the sagittal plane about a bitemporal axis. The head at once bends forwards, the arms are extended backwards and the hips and knees are flexed (*Fig.* 175). This reaction either prevents or minimizes the fall (Quix).

According to Tait and McNally the canals fall into two groups : (1) A non-gravity set, i.e., the horizontal canals which are concerned with turning movements, e.g., waltzing. (2) A gravity set—the vertical canals—which are concerned in leaping and landing again, in protection against falling and in movements in which the limb muscles are exerted in opposition to gravity. If a frog be placed on a tilt table and if the end of the table beneath the frog's head be *lowered*, the animal promptly raises its head and extends both arms, whereas if the same end of the table be *raised*, the animal's head is promptly lowered. On the other hand, if one side of the tilt table is lowered, the head and the anterior part of the body is promptly moved in the opposite direction with extension of the limbs on the lower side and flexion of the limbs on the upper side. Tait and McNally have found that injury to the semicircular canals interferes with the execution of these adjustments of the body. They believe that there is a functional correlation between the anterior vertical canal on the right side and the upper limb on the same side and, further, that
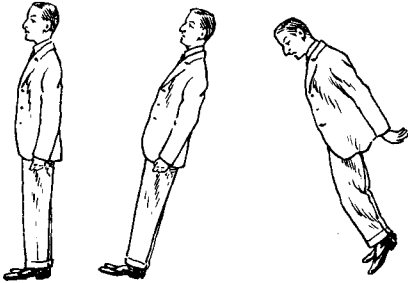
Fig. 175.—Show results of stimulation of the vertical canals produced by an accelerated rotatory movement backwards in the sagittal plane about a bitemporal axis, e.g., falling on a banana skin. (1) Rest position ; (2) Position of a person falling backwards if he had no canal reflexes ; (3) Result of canal reflexes produced by the rotatory movement— flexion of the head, extension of the arms backwards and bending of the knee which prevent or minimize the fall. (*After Quix.*)

the posterior canal on one side is functionally correlated with the lower limb on that side. McNally has removed all six semicircular canals from a frog, without other damage, and found that the animal was much more readily capsized on a tilt table than a normal frog. Over its static equilibrium, on the other hand, the decanalized frog had complete control, as this depends on the utricles. If the tilt table was inclined very slowly, the frog adjusted itself so that its body remained vertically over the base of support and its head was held horizontally.

Vestibular nystagmus is a rhythmic associated movement of the eyes and consists of a slow movement of the eyes in one direction followed by a quick return in the opposite direction. The slow movement or component of the nystagmus is the one produced by ear-stimulation. The recovery, or quick movement, is usually held to be of cerebral origin, but de Kleijn has found that the reflex arc for vestibular nystagmus in man and other animals consists of : labyrinth, vestibular nerve, vestibular

nucleus, abducens nucleus, abducens nerve and external rectus muscle. It is perhaps unfortunate that the direction of the nystagmus has been named according to the direction of the quick component, i.e., nystagmus to the right means that the quick jerk is to the right while the real vestibular component is the slow return to the left. (Nystagmus is always most marked when the patient looks in the direction of the quick component, and is lessened or abolished when he looks in that of the slow component.) Nystagmus which is present only when the patient looks in the direction of the quick component is known as nystagmus of the first degree; if nystagmus is also present when the patient looks straight in front it is said to be of the second degree; if still present when he looks in the direction of the slow component, the nystagmus is of the third degree. (This last type is seen in cases of manifest diffuse purulent labyrinthitis at the most acute stage.) A patient with nystagmus to the right is requested to look at an object on his right side. The vestibular pull causes the eyes to deviate to the left. Under the influence of an anæsthetic the quick component of nystagmus is eliminated, and the slow or vestibular movement alone takes place, and results in conjugate deviation.

Functional Examination of the Semicircular Canal Apparatus.—A careful history of the case must first be taken as regards dizziness, its duration, severity, mode of onset, and effect of sudden changes in the position of the head. Was the dizziness associated with nausea and vomiting ? Are the attacks periodic, and are they associated with any known cause ? In which direction did external objects appear to move ? Was the dizziness sufficiently severe to cause falling ? To which side did the patient tend to fall ? The question of venereal disease must also be investigated.

Spontaneous Phenomena.—

Spontaneous Nystagmus.—The patient's head is held steady in the upright position, and he is told to look straight forward and then to follow the finger of the examiner held two feet away and moved to the right and left and also up and down. Spontaneous nystagmus in any of these positions is noted. In some normal people, slight spontaneous nystagmus may be observed on looking to the extreme right and to the extreme left; this nystagmus is equal in both directions.

Spontaneous Vertigo.—The patient is asked whether he has any sensation of turning in a definite direction, or whether he feels that external objects are revolving.

Spontaneous Pointing.—Orientation means the determination of the relation of the body to space, while equilibration means the maintenance of position whether walking, standing or sitting. Pointing is a voluntary act by which the patient indicates his sense of orientation. The normal person is always aware of the location of his hand or finger in space and, with his eyes closed, is aware of the exact position of objects previously located with the finger. In carrying out Bárány's pointing test, the patient is seated and the examiner stands opposite to him. The patient shuts his eyes and extends one upper extremity with three fingers and thumb closed but the forefinger pointing forwards. The examiner also

extends his hand and brings one forefinger below and in contact with that of the patient. At the word 'Up' the patient raises his arm to the vertical position, and then immediately brings it back again to touch the examiner's finger. In the same way downward and lateral pointing may be tested. Further, the accuracy of pointing at the elbow- and wrist-joints and also in the joints of the lower extremities may be investigated ; even the pointing reaction of the head and trunk may be tried ; but, as a rule, only the reactions of the upper extremities are examined.

Spontaneous Falling (Romberg's Test).—The patient stands with heels and toes together and eyes closed, and the direction of any swaying or falling is noted. The patient is now asked to turn his head sharply to the right or left, and any change in the direction of falling is noted. The examiner now grasps the shoulders of the patient and attempts to over-throw him either to one side or the other, forward or backward. The patient is told to balance himself so that he will not fall. When the shoulders of the patient are pressed towards the right, the pelvis should sway towards the left in the attempt to main-tain equilibrium.

Induced Phenomena.—

Rotation Test.—For this test a special turning-chair is advisable (*Fig.* 176), in which the patient sits, with his feet free of the floor and his head immediately over the axis of rotation. At the back of the chair there is a rod for turning. The patient is placed in the chair with his head in the 'upright' position, i.e., inclined 30° forwards, so as to bring the two lateral canals into the horizontal plane. He is now rotated at the rate of ten complete revolutions in twenty seconds. At the end of the tenth turn the rotation is suddenly stopped, and the duration of the result-ing nystagmus is measured by a watch. When the head is in the erect position the

Fig. 176.—Jones' rotation chair as modified by Jenkins.

rotation affects the two horizontal canals, as they alone are in the plane of rotation. Rotation is said to be 'to the right' or 'clockwise' when the patient is turned from left to right in the direction of the hands of a watch held face upwards, or as in the military command, 'About turn'. At the beginning of rotation to the right, the endolymph in the right canal, owing to its fluid inertia, flows towards the ampulla, relatively speaking ; while in the left canal the fluid flows away from the ampulla (*Fig.* 174A). As the rotation is continued, the endolymph catches up with the movement of the canal wall until it rotates at the same rate. Should now the rotation of the individual be abruptly stopped, the movement of the endolymph will continue, but its flow relative to the ampulla will be in the reverse direction to what it was at the beginning of rotation (*Fig.* 174B). In order to understand the

movements of the endolymph and cristæ, it is only necessary to think of what occurs in a tramcar. When the car starts suddenly, all the passengers are violently jerked backwards, but as the car goes on they again assume the upright position, and maintain it until the car stops suddenly, when they are all jerked forwards. The cristæ of the membranous canals correspond to the passengers. The mechanism of the horizontal nystagmus to the left after rotation of the patient to the right is shown in *Figs.* 174 and 177.

Nystagmus produced by suddenly stopping the rotation of a patient is known as 'after-nystagmus'. The duration of the horizontal 'after-nystagmus' to the left in a normal individual, due to rotation to the right with the head erect, is from fifteen to thirty seconds—usually
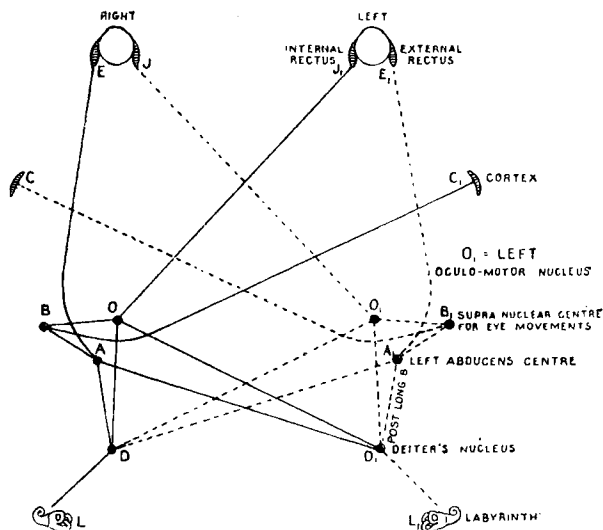
Fig. 177.—Diagram showing mechanism of horizontal nystagmus to the left, after rotation of a patient (upright position) to the right. The brain and eyes are looked at from below and in front. On the left of the diagram (the right side of the patient) is shown, by continuous lines, the path of the impulse from the labyrinth producing the slow vestibular component to the right. On the right side of the diagram, dotted lines indicate the path of the impulse from the cerebral cortex (C), which produces the rapid (cerebral) component to the left.

about twenty-four seconds. The laws of nystagmus are as follows (Bárány): (1) Each pair of canals induces nystagmus in its own plane. (2) Nystagmus due to rotation corresponds to the line of intersection of the horizontal plane with the cornea. The vertical canals may be tested by bending the patient's head forwards and to the right so that the lambda approximates to the right shoulder. This tests the posterior vertical canal on the right side and the superior vertical canal on the left side, as these two canals lie on parallel planes which in this position are also parallel to the floor. In a similar way, if the patient be rotated with his head bent forward and to the left, so that the lambda approximates to the left shoulder, the two remaining vertical canals—the posterior canal on the left side and the

superior canal on the right side—will be brought into the horizontal plane. Rotation in these latter positions, however, is apt to produce unpleasant symptoms which may last for a day or more ; for this reason patients are usually tested with the head in the upright position only. Most people are accustomed to turning in this way, as in waltzing.

If a patient is seated in a turning-chair with his head erect and is rapidly turned to the right then, on stopping the rotation, he feels as if everything were turning to the left in the horizontal plane. If the patient is rotated to the right with his head bent 90° forwards, and if he raises his head after stopping the rotation, the entire surroundings seem to topple to the left. Thirdly, if during rotation to the right he bends his head to the right shoulder and then raises it on stopping, everything in front of him seems to tumble into the depths. Lastly, if with his head in the erect position he is rotated to the right and, on stopping,

Fig. 178.—The method of testing the kinetic labyrinth employed by Tait and McNally. The patient is placed diagonally on the tilt table, one end of which is suddenly lowered.

bends his head towards the right shoulder, everything seems to fly at him and he has a sensation of falling backwards.

Pointing Reaction.—As has been stated above, after rotation to the right with head erect has been suddenly stopped, the patient feels that he is turning to the left, i.e., he suffers from vertigo. Pointing is a voluntary motor act, and the pointing error is due to vertigo. In performing the pointing test (*see above*) the patient therefore makes what he thinks is an appropriate correction, and so past-points to the right. If there is no vertigo there is no past-pointing. The duration of the past-pointing and of the vertigo are the same, i.e., about twenty-four seconds after the rotation has stopped. Past-pointing can occur in the three planes of space—horizontal, frontal and sagittal. The plane of

the past-pointing is always in the plane of the vertigo producing it, while the direction of the past-pointing is opposite to the direction of the vertigo.

Falling Reaction.—The phenomenon of falling after ear-stimulation may be regarded as a 'past-pointing' of the entire body. After rotation with the head upright, the subjective sensation of vertigo is in the horizontal plane, and the individual feels that he is being rotated on his own vertical axis, as after waltzing. There is therefore no tendency to fall. If, however, the subjective sensation is one of turning in the frontal plane, e.g., after rotation with the head bent backwards, the individual tends to fall to one side or the other. In all circumstances the past-pointing and the falling are in the direction of the slow component of the nystagmus, i.e., the direction of the endolymph movement.

In order to test the vertical canals, Tait employs his tilt table (*Fig.* 178). A normal person kneels on the table and places his hands flat on the top. When the table is tilted, no matter in which direction, the kinetic equilibrium of a normal person is perfect, provided that the angle of inclination is not too steep. On the other hand, if a patient with total loss of function of the vestibular labyrinth takes his place on the table which is tilted forwards or backwards even through an angle of only 10° or 15° he is easily upset.

Caloric Test.—The advantage of the caloric test is that each ear can be tested separately. For the cold caloric test, water at 65° F. should be used; for the hot caloric test, water at 112° to 115° F. The douche-can containing the water is placed approximately two feet above the ear to be douched (*Fig.* 179). An ear nozzle is attached to the tubing coming from the douche-can. The patient's head is tilted 30° forward.

Douche-can and rubber tubing

Waste tank

Fig. 179—Brünings' apparatus for production of caloric nystagmus. (For the sake of clearness the figure of the assistant who holds the ear-piece has been omitted.)

The douching is carried out by a nurse while the surgeon notes the onset of nystagmus and an assistant, with the aid of a watch, observes the number of seconds from the beginning of syringing to the occurrence of nystagmus. In normal cases the caloric reaction appears in from fifteen to thirty seconds. In cases with granulations, small polypi, etc., the reaction may take from two to three minutes. Douching is continued five to ten seconds after the first appearance of nystagmus. The pointing and falling tests are then carried out.

Cold syringing of the left ear causes a downward current in the endolymph of the superior canal from the convexity over the crista into the utricle (*Fig.* 180), and gives rise to rotatory nystagmus to the right—the slow or vestibular component being directed to the left. If now the head be tilted so that the eyes look to the ceiling, the horizontal canals become vertical and the former rotatory nystagmus becomes horizontal to the right (*Fig.* 181). If the fluid used be at body temperature there is, of course, no reaction. If the vestibular apparatus be destroyed, or the vestibular nerve be paralysed, nystagmus cannot be induced by syringing. When rotatory nystagmus to the right is produced in a normal person, he tends to fall to the left; if now his head be turned 90° to the right, he falls forwards. The tendency to fall is always in the direction of the flow of endolymph.

In cases in which there is a dry perforation of the drumhead, or in which the caloric test has to be carried out with the patient in the recumbent position, the 'cold air' apparatus of Dundas-Grant will be found convenient. Ruttin in such cases uses the Junker anæsthetic apparatus with ether vapour.

Fig. 180.—Mechanism of rotatory nystagmus produced by syringing the ear with cold lotion (semidiagrammatic); (1) Endolymphatic space of superior vertical canal; (2) Perilymph space; (3) Crista and cupula of superior canal: the arrows show the direction of the endolymph current produced by the cold syringing; (4) Cavity of utricle; (5) Perilymphatic space of vestibule; (6) Central vessels and lymphatics in nucleus of labyrinth; (7) Stapes. The large arrow shows the direction in which the cold is applied when the ear is syringed.

Arm Tone Reaction. — Wodak and Fisher have described the arm tone reaction (A.T.R.). It depends upon the fact that if the vestibular
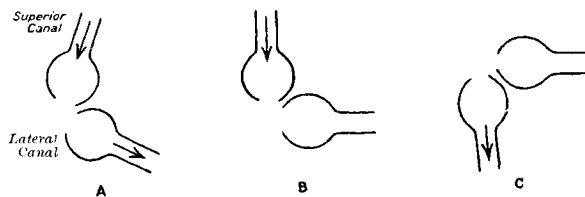
Fig. 181.—Diagram to explain the caloric test with cold water. The left ear is being syringed with cold water, and the downward direction of the endolymph flow in the superior and lateral canals is indicated by the arrows in the three different positions of the head. (A) Normal upright position; (E) Head tilted 30° forward; (C) Head tilted 60° backward

apparatus of a normal individual is stimulated as, for example, by syringing with water, there occurs an alteration in the subjective feeling of weight on the two sides of the body. The individual is asked to close

his eyes and to extend both arms horizontally before him, in the position of pronation. If cold water is used, the sinking is in the first instance on the syringed side ; if warm water, the reverse. The reaction endures from fifteen to thirty minutes. During this time there often occurs a reversal, both subjective and objective, in that the arm which at first felt the heavier now becomes the lighter and rises.

Electrical Test.—The galvanic test affects not only the labyrinth but also the eighth nerve, and is of importance in the diagnosis of tumours of this nerve. In destruction of the labyrinth due to labyrinthitis, and also in tumours of the eighth nerve, there are deafness, nystagmus and vertigo, with loss of caloric reaction. In the former case (labyrinthitis) the vestibular nerve is still intact, and electrical stimulation produces normal or almost normal responses. In tumours of the eighth nerve, however, the vestibular nerve itself is involved and does not react to galvanic stimulation. The patient is first of all tested for spontaneous nystagmus. Both electrodes should be wrapped in gauze soaked in saline solution. The large flat electrode is held by the patient—it is immaterial in which hand. The examiner elevates the upper eyelid of the patient with the thumb of one hand, while applying the ball electrode with the other hand to the tragus so as to push it into the external canal. The moment a reaction is observed, the assistant is notified and announces the milliamperemeter reading. Taking the figures of McKenzie, the normal reaction from the combined inner ear and nerve is : Right ear: kathode 4 ma., nystagmus to the right ; anode 4 ma., nystagmus to the left ; Left ear : kathode 4 ma., nystagmus to the left ; anode 4 ma., nystagmus to the right. The galvanic reaction is explained as follows : tonic impulses from the right ear continually tend to draw both eyes to the left. If the anode is applied to the right ear, the function of this ear is depressed and so a drawing of both eyes to the right is produced, with consequent nystagmus to the left. The kathode has the opposite effect. (Note that the galvanic reaction as described above sometimes causes so much pain as to render the method unreliable or even useless.)

Bourgeois states that if in a normal individual the two poles of a continuous current are applied one in front of each ear, there is an inclination of the head and trunk towards the positive pole when the current reaches a sufficient strength—usually 5 ma., though nystagmus can usually be induced by 3 ma. if the patient is made to look in the direction of the quick component. The patient stands with heels together and eyes shut, while an assistant gradually increases the current until the reaction is obtained, and then diminishes the current to zero. During the flow the patient experiences a feeble vertigo with a lateral impulse towards the positive pole—an impulse which it seems practically impossible to resist. In hyper-excitability of the vestibular apparatus the reaction is obtained with less than the usual number of amperes. In hypo-excitability even 15 ma. fail to produce the slightest vertigo while in some cases no reaction can be produced.

Condensation and Rarefaction of the Air in the External Meatus (Compression Nystagmus or Fistula Symptom).—This method is of use in

cases in which the bony wall of the lateral semicircular canal has been eroded by disease, with exposure of the endosteum. The condition is known as 'fistula' of the lateral canal. The reaction to the fistula test presupposes a live or functioning labyrinth. The test is carried out as follows : an olive-shaped ear-piece is attached by means of rubber tubing to a valveless Politzer bag ; the ear-piece is fitted tightly into the meatus. The patient is directed to look straight forward. By suddenly squeezing the rubber bag the air-pressure in the meatus is raised, and the pressure is transmitted to the fluid in the labyrinth through the gap caused by the erosion. By releasing the bag without removing the ear-piece the pressure in the meatus is diminished. The direction of the nystagmus produced in this way cannot always be accurately predicted, but the effect of rarefaction is always the opposite of that due to condensation. In the 'typical' fistula symptom, on compression, nystagmus is produced to the diseased side—the slow movement being to the opposite side. In the 'reversed' fistula symptom, on compression the nystagmus is to the healthy side, and the slow component to the diseased side. (The reversed fistula symptom may be produced in cases of undue mobility of the stapes.)

Examination of the cochlear and vestibular apparatus by the methods described above is of use, not only in the diagnosis of labyrinthine and intracranial lesions produced by middle ear suppuration but also in the investigation of tumours and vascular affections of the brain. Staunton Wishart points out that : (1) Lesions of the labyrinth and eighth nerve produce loss of function of both cochlear and vestibular apparatus. (2) Cerebellar lesions interfere with the function of the vestibular apparatus, but leave the hearing intact ; in intracerebellar growths the interference with the vestibular function tends to be bilaterally symmetrical ; further, the functions of both vertical canal reflex-arcs are affected before those of either horizontal canal. Jones and Fisher hold that, while a cerebral cortical area provides energy 'in the rough', the cerebellum supplies the necessary synergy for bodily movements. In order to carry out a definite movement more than one muscle has to contract if precision is to be attained. Accordingly the cerebellar cortex contains various centres, e.g., an outward-pointing, an inward-pointing, an upward-pointing and a downward-pointing centre for the upper extremity. When an individual desires to move his upper extremity downwards and touch a certain point, the cerebral cortex supplies the energy, but the necessary precision is furnished by the cerebellum. The centres concerned in this particular movement are the outward- and inward-pointing centres for the corresponding extremity. These two act against each other so that the arm is brought down in a perfectly straight line even when the patient's eyes are shut. Cerebellar cortical representation is homolateral, the right side of the cerebellum supplying synergy for the right side of the body. The various centres have been more or less mapped out on the upper and lower surfaces of the cerebellar hemispheres and in the vermis. If the superior lobe is affected, the upper limb is involved, and correspondingly with the inferior lobe and lower limb. The superior vermis controls the shoulder girdle, and the inferior

vermis the pelvic girdle. (3) Lesions above the tentorium cerebelli, though they may be associated with occipital headache and vertigo, do not alter the normal responses obtained from the cerebellum and the vestibular apparatus.

Sea-sickness.—Gwynne Maitland states that sea-sickness is predominantly of vestibular origin and is due to the movement of the endolymph mainly in the vertical semicircular canals.

With the exception of certain rare individuals and a few pathological cases (acquired deaf-mutes, p. 432) all normally constituted people are susceptible to some definite type of movement. The most unpleasant movement is what is called 'corkscrew', i.e., when the seas are on the bow or quarter—a combination of roll and pitch. Whatever the ship's movement may be the passenger can only partially counteract it by bodily adjustment. He is well advised, however, to lie 'fore and aft' for roll, or 'athwart' for pitch, as in these positions it is the lateral and not the vertical canals which are stimulated.

The opinion has been advanced that the vestibular apparatus can have no relation to sea-sickness because nystagmus has not been observed in sea-sickness, while it always follows rotation in a turning-chair. Rotation, however, when conducted so as to simulate the movements of a ship, can produce the syndrome of sea-sickness without any nystagmus. Vomiting is due to reflex stimulation of the vagal motor fibres to the stomach.

Certain patients derive considerable benefit by closure of the eyes as they may be a contributory factor in the production of sea-sickness. Alternatively the eyes may be fixed on a book.

(The medical treatment of sea-sickness need not be discussed here.)

ulcerative conditions of the pharynx or larynx, from affections of the posterior group of paranasal air-sinuses, or perhaps most frequently of all from an embedded wisdom tooth or from a carious molar in the mandible.

When the pain is due to an inflammatory condition in the external ear, such as a boil, it is increased by pulling the auricle, by pressure over the tragus, or by the act of mastication, while the pain resulting from middle ear inflammation is aggravated by any act, like sneezing, blowing the nose, or yawning, which tends to increase the intratympanic pressure. In inflammation of the mastoid process, the pain is felt behind the ear and is generally increased by pressure over the painful area. Pain and swelling over the mastoid process may be due either to acute mastoiditis, a boil in the meatus, or in children to an inflamed postauricular gland, the last-named condition being as a rule secondary to pediculosis capitis or impetigo of the scalp.

4. **Tinnitus Aurium,** or a subjective sensation of sound in the ear, is a very common, and sometimes the only, symptom of ear disease. Tinnitus may be regarded as a sign of irritation of the cochlear mechanism, just as pain is a sign of irritation of a sensory nerve. The sounds may be continuous or intermittent and they may be synchronous with the pulse. In cases of otitis media pulsating noises are frequently met with. The patient is sometimes conscious of tinnitus during the whole of his waking hours, or he may hear the noises only when in a quiet room, or when in bed at night. Tinnitus may produce extreme depression and may render the patient unfit for work. The nature of the sounds varies; they may be described as buzzing, roaring, rushing, hammering, as being like the escape of steam, the sound of the sea, or of bells, and so on.

Tinnitus may be met with in any form of ear disease and is also a symptom of some general diseases which indirectly affect the ear through the circulation ; thus in renal affections, cardiac disease and anæmia it is a common symptom. Certain drugs, such as quinine and the salicylates, frequently cause tinnitus, which is also met with in intracranial tumours.

5. **Vertigo** is fairly common in cases of ear disease and must be looked on as a symptom of irritation of the vestibular apparatus. It may in rare cases be produced merely by the pressure of cerumen against the drum membrane. It is also met with in affections of the middle and internal ear, especially in cases in which the bony wall of the horizontal (lateral) semicircular canal is eroded by disease. In this condition giddiness is experienced on stooping or on suddenly turning the head. Neuritis of the vestibular nerve may be due to toxæmia. Tumours of the eighth nerve and cerebellar lesions, such as abscess or tumour, also give rise to vertigo. Arteriosclerotic changes in the blood-vessels of the brain are a common cause of giddiness in old people. In some cases vertigo is more or less constantly present ; it is then rarely severe.

OTOSCOPIC EXAMINATION.

In examining the ear good illumination is necessary. Any fairly powerful lamp such as an electric bull's-eye lamp, an incandescent gas mantle, an Argand burner, or a paraffin lamp will answer the purpose.

Daylight may suffice if reflected into the ear while the patient sits at a window. The ordinary forehead mirror with a focal distance of about six inches may be used, but better illumination can be obtained by means of a smaller mirror with a shorter focus (four inches) ; this mirror may be fixed to a forehead band, or it may be held in the hand, in which case it is provided with a handle. The light is arranged on one side of the patient's head and slightly above the level of his ear (*Fig.* 182). The patient is seated sideways to the surgeon who sits opposite the ear to be examined and reflects the light on it; but, before introducing the speculum, he should examine the mastoid process and note any abnormality, such as a scar, redness, œdema, etc. He should also inspect the meatus ; this will enable him to detect any swelling or irritation of the skin about the meatus, and will guide him as to the size of the speculum to be used. In order to see the drum membrane it is necessary to straighten the external auditory meatus by pulling the auricle upwards, outwards and backwards. In infants, owing to the non-development of the bony external meatus, the auricle has to be drawn downwards and backwards. In a considerable proportion of cases these manipulations permit of an inspection of the meatus without the use of a speculum. But when vibrissæ interfere with the view, or when the outer part of the passage is slit-like, as is frequently the case in elderly individuals, it is necessary to make use of the speculum. A metal

Fig. 182.—Otoscopic examination.

instrument should be used, but it is immaterial what pattern is selected. One with a bell-shaped mouth, such as Pritchard's, is preferable, as it is convenient to handle and facilitates the introduction of instruments ; on section the speculum may be circular or oval. The surgeon should provide himself with three or four different sizes to suit all ages. To introduce the instrument, the auricle is pulled up by the middle and ring fingers, and the speculum, held between the thumb and index finger (*Fig.* 182), is gently inserted into the meatus ; if vibrissæ obstruct the view, it is given a rotary movement. It should not be pushed in far enough to come in contact with the bony meatus. as this part of the canal is exceedingly sensitive.

On looking into the meatus, the skin of the posterior inferior meatal

wall will probably meet the eye first. In order to inspect the drumhead it is necessary to direct the gaze forwards and upwards as well as inwards. In health, the drum membrane presents a highly polished grey surface (*Plate XVI*, 1) of which the posterior and upper part is distinctly nearer the eye than the anterior and inferior. The colour alone is not sufficient for the recognition of the membrane ; the handle of the malleus must also be seen. At the upper end of the handle, the lateral or short process is noted as a small projection ; and running downwards and backwards from this, the handle of the malleus appears as a whitish-yellow streak ending at a point, the umbo, below the centre of the membrane. For purposes of description the membrane is divided into four quadrants by imaginary lines, one of which is dropped perpendicularly from the umbo, while the other bisects this line at right angles (*Fig.* 183). Extending downwards and forwards from the umbo, the cone-shaped light reflex is seen. This is fairly constant in position, as the anterior inferior quadrant of the membrane is the only part that is approximately at right angles to the meatus and therefore in a position to reflect the light from the mirror. The reflex may be absent owing to the loss of polish, or it may be altered in position by changes in the curvature of the membrane which, it will be remembered, is concave on its lateral surface. In front of and behind the short process two folds are seen on the membrane ; these are called the anterior and the posterior folds. They are only very slightly marked in the normal membrane, but become greatly exaggerated in cases of in-drawing (*Plate XVI*, 2). Immediately above the short process the *membrana flaccida*, or Shrapnell's membrane, fills the gap in the tympanic ring known as the notch of Rivinus.
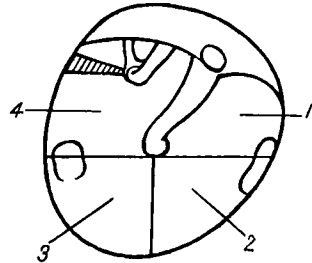
Fig. 183.—Diagram of right tympanic membrane. (1) Anterior superior quadrant ; (2) Anterior inferior quadrant ; (3) Posterior inferior quadrant ; (4) Posterior superior quadrant.

The translucency of the drumhead varies considerably in health and, while the above description refers to one of average translucency, additional structures may be seen when the membrane is more transparent. The long process of the incus is frequently observed ; it appears as a white line behind the handle of the malleus and lying parallel to it (*Plate XVI*, 1), but extending along only about half its length. It is sometimes seen to end in a round spot which is the head of the stapes. At right angles to this, and extending to the posterior margin of the membrane, the tendon of the stapedius muscle presents a similar appearance. In the lower and posterior quadrant a round shadow may be seen at the circumference of the membrane, which corresponds to the niche leading to the fenestra rotunda. The centre of the membrane is of a pale-yellow colour due to the promontory shining through ; for it will be remembered that the promontory is convex outwardly, while the membrane is concave ; thus the inner wall of the tympanum is much closer to the membrane at the centre than at the circumference.

PLATE XVI.

VARIOUS APPEARANCES SEEN ON EXAMINATION OF THE DRUMHEAD.

1. Normal right tympanic membrane.

2. Markedly indrawn left drumhead, with prominence of the anterior and posterior folds. The handle of the malleus is greatly foreshortened.

3. Left drumhead. Seromucous middle ear catarrh. Note the hair line at the upper margin of the exudate.

4. Right drumhead. Acute catarrhal otitis media. The superficial vessels are seen radiating from the handle of the malleus.

5. Right drumhead. Acute suppurative otitis media during influenza, with hæmorrhagic bullæ on the drum membrane.

6. Right drumhead. Acute suppurative otitis media, with bulging of posterior superior quadrant.

7. From same patient as No. 6, showing appearances during healing process.

8. Right drumhead. Tuberculous otitis media with two perforations of the drumhead.

9. Chronic purulent otitis media, left ear, with anterior central perforation. Posteriorly the drumhead shows a chalk patch.

10. Chronic purulent otitis media, left ear, showing very large central perforation.

11. Chronic purulent otitis media, right ear, with granulations covering the posterior superior quadrant.

12. Chronic purulent otitis media, right ear, with granulations and cholesteatoma.

13. Chronic purulent otitis media, left ear, showing large posterior marginal perforation and cholesteatoma.

14. Perforation of Shrapnell's membrane (attic perforation), left ear, with cholesteatoma.

15. Kidney-shaped scar in right drumhead, resulting from former middle ear suppuration.

16. Results of chronic middle ear suppuration in right ear. Anteriorly there is a chalk patch in the drumhead, and posteriorly a large perforation, showing the entrance to the round window niche.

17. Results of chronic suppuration in right ear. There is a large chalk patch in the drumhead, and a posterior marginal perforation, revealing the joint between the incus and stapes.

18 Large retracted scar in left drumhead, resulting from former chronic suppuration.

19. Shows the same ear as seen in No. 18, after inflation. The scar is now bulged outwards towards the meatus.

20. Otosclerosis. The normal transparent left drumhead shows a pinkish tinge of the promontory in the region of the oval window.

PLATE XVI

AFFECTIONS OF THE DRUMHEAD
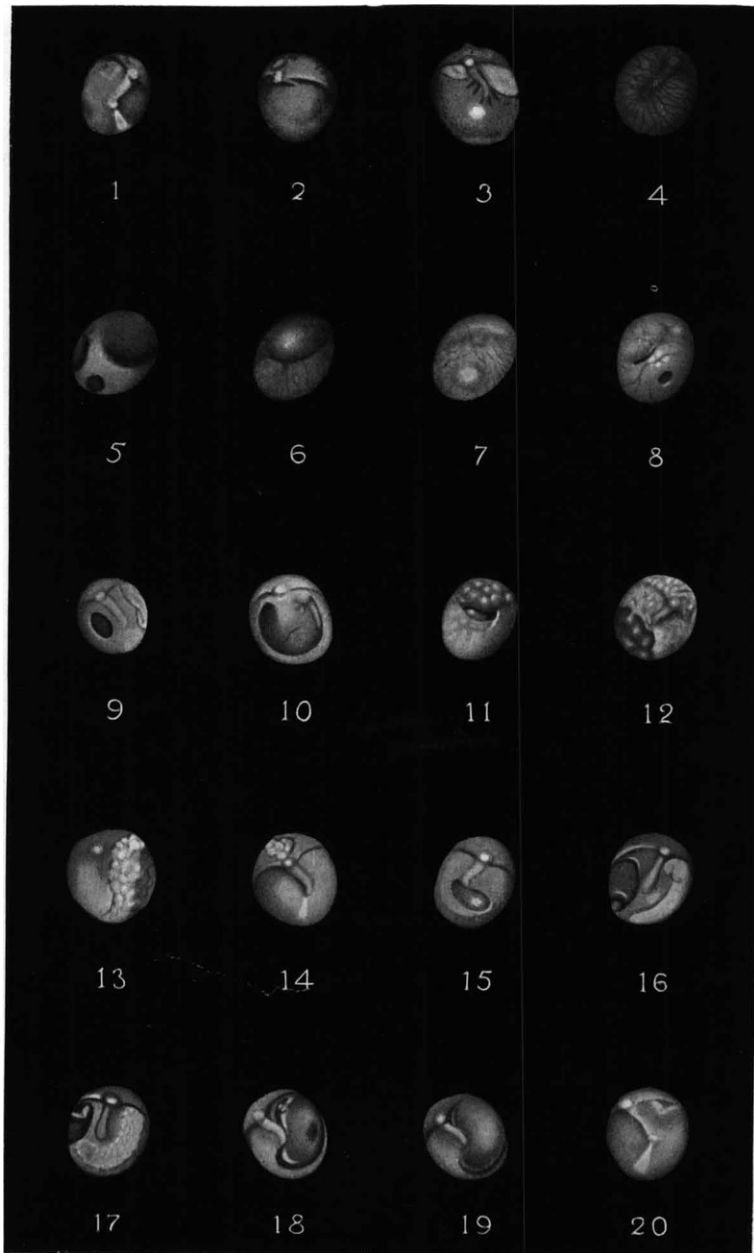
Finally, it is occasionally possible to see the tympanic opening of the Eustachian tube through the most anterior part of the drumhead. While the normal membrane is readily recognized after a little practice, the beginner will experience considerable difficulty in distinguishing many abnormal conditions. In such cases, the short process and the handle of the malleus should be looked for in the first instance, because, if these are seen, there is no doubt that the structure they lie in is the drum membrane, however much its appearance may be altered. When, however, they are not detected, the observer must attempt to estimate the depth of the structure at which he is looking. If it is obviously nearer the eye than the membrane, the appearances may be due to a polypus, granulation, wax, a foreign body, or to some projection from the meatal wall. Finally, when the appearances are not comparable with any condition with which the observer is familiar, the ear should be syringed, as the presence of even a very little pus or a flake of wax or desquamated epithelium may be quite misleading and give rise to an incorrect diagnosis.

It is convenient here to describe some of the more common pathological conditions found in the membrane. A minute perforation appears as a black spot, because, being small, the middle ear is not lit up ; but a larger perforation is always clean-cut unless it is due to traumatism, in which case the edges may be ragged. A cicatrix is usually very transparent and may appear like a dry perforation (*Plate XVI*, 18) ; but unless it is adherent to the inner wall of the middle ear it may readily be distinguished from a perforation by means of a Siegle's speculum. This is a speculum which expands into a small chamber and is closed at its outer end by a lens. A small hollow peg, to which a rubber ball with rubber tubing is attached, is let in at the side. The speculum is introduced into the meatus which it should fit closely ; the distal end of the speculum should therefore be covered with a small piece of rubber tubing. On looking through the lens an enlarged view of the drumhead is obtained. If the rubber ball is now alternately compressed and released, the air in the chamber and external auditory meatus will be alternately condensed and rarefied. In the case of a cicatrix each movement of the rubber ball makes it flap in and out (*Plate XVI*, 18, 19), while a perforation shows no movement, though, if the middle ear is not quite dry, some secretion may be sucked out through the perforation.

An indrawn membrane presents characteristic appearances (*Plate XVI*, 2) ; the short process is prominent and causes the anterior and posterior folds to be very much exaggerated, especially the latter, which frequently present a sickle shape. The hammer handle is foreshortened and rotated, so that it lies in a more backward direction than usual, and the greater part may actually be hidden behind the posterior fold. The change in direction of the handle brings the umbo into the upper half of the membrane ; and, finally, the altered curvature of the drumhead displaces the light reflex which accordingly appears as a mere spot of light at the periphery.

Other pathological conditions will be described later.

Inflation.—To complete the examination of the ear, it is necessary to try the effect of inflation of the middle ear cavity. By this is meant

20

driving air through the Eustachian tube into the tympanum. This procedure is important in diagnosis and prognosis, and also as a method of treatment. It is of importance in diagnosis, in that it gives information as to the patency of the Eustachian tube, it demonstrates the presence of abnormal secretions within the middle ear cavity and, finally, it gives information as to the site of the lesion by its effect on the acuity of hearing. It is of value in prognosis, as this depends largely on the immediate improvement of hearing after inflation and on the length of time the improvement lasts. Its application as a method of treatment will be considered later.

Inflation may be performed by Valsalva's experiment, by Politzer's method or one of its modifications, or by means of the Eustachian catheter. In Valsalva's experiment the patient closes both nostrils and makes a forced expiration with his mouth shut. If the Eustachian tube is patent, air passes into the tympanum, and the patient feels a crack, or a sense of fullness in the ears. If the membrane is inspected during inflation, it is seen to move if there is nothing to interfere with its mobility. Valsalva's experiment is not always successful, even when the tubes are patent, and one of the other methods should generally be employed.

Politzer's method is carried out by means of a Politzer bag, the nozzle of which is protected by a small piece of rubber tubing, which should be changed for each patient. The nozzle is inserted into one nostril, and both nostrils are then tightly closed by the finger and thumb of the surgeon's left hand, the bag being held in his right hand. The patient, who has previously taken a sip of water into his mouth, is now told to swallow, and the moment he does so the bag is forcibly squeezed. The most effective moment at which to compress the Politzer bag is that at which the larynx rises at the beginning of deglutition. This can easily be ascertained by watching the patient's neck. Part of the air thus driven into the nose will pass into the middle ear on each side through the Eustachian tubes, unless they are very much blocked. Various modifications of Politzer's method have been suggested and, as they are less forcible, may be advantageously applied in the first instance. Holt's modification consists in merely puffing out the cheeks during the compression of the bag. Gruber suggested making the patient say the word 'huck'. In the case of children, the bag may be compressed during the act of crying.

When Politzer's method fails, or it is desired to inflate one ear only, catheterization must be employed. The Eustachian catheter is a tube of metal or vulcanite, of which the inner end is curved, while the outer extremity is expanded to permit the insertion of the nozzle of a Politzer's bag, and is also provided with a ring which points in the same direction as the beak. Catheters vary in calibre and in the amount of curve, and the surgeon should be provided with at least three different sizes. Before using the catheter, the hearing of the ear under examination should be tested by the whisper or conversation voice (p. 277) and the nose should be examined to see if there is any obstruction of the passage ; and in the case of sensitive or nervous individuals, it will render the procedure

much less disagreeable if a probe, dressed with cotton-wool and dipped in 10 per cent solution of cocaine, has been previously passed once or twice along the lower part of the nasal cavity. For the passage of the catheter, the patient should be seated with head erect, while the surgeon stands opposite him and a little to the right. An auscultating tube connects the surgeon's ear with that of the patient. This is a rubber tube, provided with an ear-piece at either end, one being white and the other black. The surgeon reserves the white one for his own ear, and the other should always be cleaned after use. The surgeon places a Politzer bag under the left armpit, with the bag to the front ; it is thus readily grasped when required. He holds the catheter between the
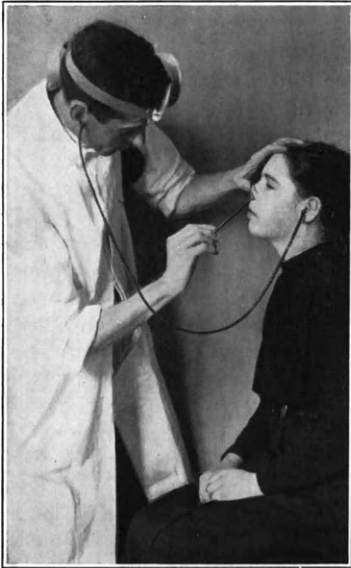
Fig. 184.—Introduction of Eustachian catheter
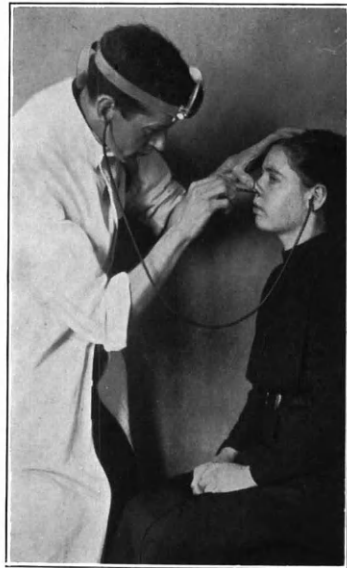
Fig. 185.—Introduction of Eustachian catheter.

finger and thumb of his right hand and gently tilts up the point of the patient's nose with his left thumb, while he gives support to that hand by resting his fingers upon the patient's forehead (*Fig.* 184). The point of the catheter is now introduced into the nose ; as soon as it is within the nostril, the right hand, which was previously at a lower level than the beak, is raised until the catheter assumes a horizontal position, when it is pushed gently backwards along the floor of the nose until it impinges on the posterior wall of the nasopharynx (*Fig.* 185). The surgeon then steadies the catheter by catching hold of it between the thumb and index finger of the left hand at the point where it enters the nose ; in the subsequent movements the catheter is allowed to slip through his finger and thumb which remain stationary. The catheter is next rotated through a right angle medially and is withdrawn until it catches

on the posterior free margin of the septum. Finally it is rotated through two right angles, or a little more, in a lateral direction, and this manœuvre should bring the point of the catheter to the mouth of the Eustachian tube, and the ring at its outer end should be directed towards the lateral canthus of the patient's eye.

It may be advisable for the sake of clearness to recapitulate shortly the stages of passing the catheter : (1) Introduce the beak of the catheter into the nostril (*Fig.* 184) : (2) Raise the catheter to the horizontal plane ; (3) Push it straight back until it impinges on the wall of the nasopharynx (*Fig.* 185); (4) Rotate it through a right angle medially ; (5) Withdraw it until it hitches on the free posterior margin of the septum ; (6) Rotate it through two right angles in a downward and lateral direction (*Fig.* 186).
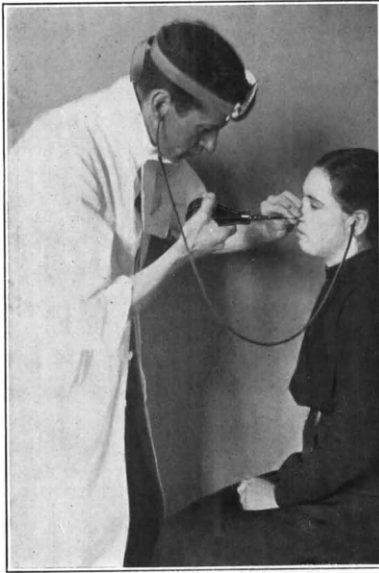
Fig. 186.—Introduction of Eustachian catheter.

The beak of the catheter is then in position. The surgeon now takes the bag in his right hand, and, introducing the nozzle into the expanded end of the catheter, squeezes the bag ; air should then pass into the middle ear and the auscultatory phenomena must be observed. When the tube is patent, air passes freely into the middle ear and is heard through the auscultation tube as a definite blowing sound. When the tube is partially obstructed the sound is less distinct. If there is fluid in the middle ear faint cracklings may be heard. In many cases of perforation the sound appears much closer, almost as if the air had passed direct into the observer's ear ; but if the perforation is quite small a whistling sound is produced.

Difficulties in the Passage of the Catheter.—If the nostril on one side is blocked, the catheter may be passed through the opposite nostril ; only one rotation is then required, and an instrument with a longer beak must be selected. If the nasal passages are free, and if cocaine is used in the case of sensitive individuals, it is not difficult to pass a catheter ; beginners, however, frequently make the mistake of pushing it well into the nose before raising it to the horizontal position, with the result that the beak passes above the level of the inferior concha, whereas it ought to be kept along the floor of the nose. Another difficulty is produced by too much handling of the catheter when it has passed into the nasopharynx ; this often causes spasm of the soft palate and locking of the catheter. In such cases a pause must be made until the spasm has

subsided. Occasionally the catheter is correctly passed, but there is difficulty in driving air into the tube. In such cases the patient should be asked to swallow and the bag must be compressed at the moment of swallowing ; this will frequently enable the air to pass, but if it still does not do so, the question arises as to the desirability of employing bougies. As a rule these instruments are unnecessary, but in some cases air passes more readily after their use. The bougie is introduced through the catheter after the latter is in position, ink-marks having been previously made on it to show when its end has reached the beak of the catheter, and also at points half an inch, one inch and one and a half inches beyond this. The bougie should not be passed more than one inch into the Eustachian tube ; in other words, it should not be passed beyond the third ink-mark.

There are several other methods of passing the catheter, but that described above is the most reliable and generally the easiest. Some authorities prefer to make only a single rotation laterally after the posterior wall of the pharynx has been reached ; the point of the catheter is then drawn forward over the cushion of the Eustachian tube to its mouth. Another method is to use the soft palate as the guide for the distance that the catheter has to be withdrawn.

After inflation has been carried out by one or other of the methods just described, the hearing must again be carefully tested and the results noted.

The respective merits of inflation by politzerization and by catheteriza-tion must now be considered. Politzerization is easier to carry out, is less disagreeable to the patient, and an intelligent person can do it for himself if it is necessary for treatment, while it is almost the only method that can be employed in children. It has, however, the disadvantage that its effect cannot be limited to one ear, so that, if used constantly in a case where one ear alone is affected, it may cause stretching and slacken-of the drumhead on the healthy side, with resulting impairment of hearing.

The advantages of the catheter over Politzer's method are : that the action can be confined to one ear, the force of the inflation can be much more readily regulated, and the auscultatory phenomena be more easily observed.

GENERAL THERAPEUTICS.

Syringing the Ear.—The most useful type of syringe for this purpose is of brass or plated or rustless steel. It is practically impossible for a patient to syringe his own ear efficiently. Any competent person may, however, after a little training, learn to carry out this simple procedure. Sterile saline solution of boracic lotion (1–40), warmed to a comfortable temperature (100° F.), should be made use of for syringing. After filling the syringe, bubbles of air must be expelled by pressing on the piston while the point of the syringe is raised. The patient should be seated ; a towel is laid over his shoulder, and a bowl is held immediately below his ear and in close contact with the skin, to catch the lotion. The auricle is pulled upwards and backwards, and the fluid is injected along the upper wall of the meatus (*Fig.* 187), the parts being well illumined

by direct or reflected light. Excessive force must not be exerted. In attempting to remove hard wax which will not come away easily, it is advisable to soften the mass first by the instillation of a lukewarm saturated solution of bicarbonate of soda.

Intratympanic Syringing.—It is sometimes desirable to syringe the middle ear directly—for example, in cases of attic suppuration or of perforation extending to the annulus tympanicus. The method was introduced by Schwartze. Intratympanic syringing should be undertaken only by a trained otologist, as injury to the stapes and oval window or to the facial nerve may result from the unskilful use of this method. Hartmann's or Milligan's instrument may be employed ; the former consists of a fine cannula, bent up at one extremity, and with a piece of rubber tubing, terminating in a small rubber ball, attached to the other end. The instrument is sterilized, and filled with warm sterile saline solution. The point of the cannula is then introduced into the tympanum through the perforation, under guidance of the eye, and the lotion is slowly squeezed out of the ball. The process may be repeated three or four times. Finally, inflation of the ear should be carried out, partly to expel the fluid remaining in the tympanum, and partly to obviate the giddiness which is generally produced.

Fig. 187.—Syringing the ear.

The ear should be dried in every case after syringing. When the syringing is carried out at home, the drying should be left entirely to the patient. The non-luminous end of a match is dressed with cotton-wool ; it is then passed deeply into the meatus, the auricle being pulled upwards and backwards by the patient who passes his other hand round the back of his head and so grasps the helix. The wool is sterilized and stored in a glass bottle, enough being removed on each occasion by a pair of forceps, the ends of which have been previously passed through a flame.

Introduction of Medicated Solutions into the Meatus.—Among the drugs most commonly employed for instillation into the meatus are carbolized glycerin, rectified spirit, peroxide of hydrogen in solution and menthol in liquid paraffin. These solutions, with the exception of the rectified spirit, should be slightly warmed before use. The method

of introduction is simple : the patient bends his head to one side, the affected ear being uppermost ; the auricle is pulled upwards and back-wards, and about ten drops are poured into the meatus from a small (sterilized) teaspoon ; the tragus is pressed immediately afterwards to drive the fluid inwards and expel air-bubbles. After the lapse of about five minutes the fluid is allowed to escape and the ear is dried, unless more than a temporary action is required, in which case a pledget of cotton-wool is inserted into the meatus to prevent the escape of the drug.

Insufflation of Powders.—Some cases of otorrhœa are much benefited by the use of powders. The method of employment is as follows : after the ear has been syringed and dried, the powder is blown in by an insufflator with a fine straight nozzle, only a sufficient quantity of powder being used to form a thin film.

Caustics may be employed to destroy small granulations or the stumps of polypi. The electric cautery, a bead of chromic acid fused on a probe, or solid silver nitrate may be used for this purpose. The caustic should be applied under guidance of the eye. If too wide an area is burnt, the action can be stopped at once by the instillation of a solution of chloride of sodium when nitrate of silver has been used, and of bicarbonate of sodium in the case of chromic acid.

Anæsthesia in Aural Operations.—For major operations a general anæsthetic is usually required, while for minor operations local anæsthesia is generally sufficient, except when dealing with nervous children.

A watery solution of cocaine has but little effect in the ear. Bonain's or Blegvad's formula (*see* Appendix) will, however, be found more useful, for it is of service even in inflammatory conditions. It is applied by means of a small piece of cotton-wool dipped in the mixture and packed against the tympanic membrane by the insertion of further pledgets of cotton ; the anæsthetic should remain in position for fifteen minutes. A more complete anæsthesia may be obtained by injecting a 0·5 per cent solution of novocain (containing a few drops of a solution of adrenalin chloride, 1–1000) under the skin at the upper and posterior part of the meatus. This is done under guidance of the eye by means of Neumann's syringe. A little practice is required before a successful injection can be made. The procedure has been extended, and Neumann and Alexander state that they have performed radical operations on the ear painlessly by this method. In such cases some of the solution is also injected below the periosteum over the mastoid process (*see* p. 344).

Operations.—Most instruments constructed for use in the external acoustic meatus are bent at an angle of rather over 90°, with the object of bringing the hand below the line of vision when the instrument is being used. During the routine examination of the ear, a pair of angled forceps, such as Politzer's, should be at hand to remove shreds of epithelium or flakes of wax. Probes of two kinds are also required : the one fairly stout, ending in a screw thread which may be dressed with cotton-wool and employed as a mop ; and the other slender, for use as an aid to diagnosis. It is also advisable to have a set of knives, curettes and hooks which can be fixed in a common handle. A useful form of knife for incising the membrane is one with a small sickle- or diamond-shaped blade,

while for incision of furuncles in the meatus a tenotomy knife is well suited. Various forms of aural snares have been devised, of which Wilde's pattern, or one of its modifications, is probably the best. It is threaded with fine copper wire. In dealing with polypi too small to be snared, a ring knife or curette may be used. Double curettes may also be employed for this purpose.

Rarefaction and Condensation of Air.—The value of rarefaction and condensation of the air in the meatus as a means of diagnosis in eliciting vestibular nystagmus, and in distinguishing between cicatrices and perforations, has already been discussed.

As a method of treatment it is less important, though at one time it was greatly in vogue, especially for the relief of tinnitus and in chronic adhesive processes in the middle ear. For this purpose Delstanche's rarefacteur may be used, or, if very rapid alternations are desired, an air-pump driven by an electric motor may be obtained.

CHAPTER XXXV

DISEASES OF THE EXTERNAL EAR AND AFFECTIONS OF THE DRUMHEAD.

CONGENITAL MALFORMATION OF THE AURICLE.

MALFORMATION of the auricle and congenital meatal atresia (*Fig.* 188) are due to maldevelopment of the first pharyngeal cleft and the first and second visceral arches. The tympanum, malleus and incus are also involved. Several varieties of auricular deformity are described, varying from slight cases, such as pointed or Darwinian ears, to total absence of the external ear. In marked cases of meatal atresia the tympanic membrane is defective or even absent. The meatal atresia itself may be membranous or bony. (As the otic vesicle, from which the membranous labyrinth is formed, develops earlier than, and quite independently of, the external and middle ears, the labyrinth is usually normal in these cases.) The condition is as a rule unilateral. Facial p a r e s i s, maldevelopment of the mandible, hemiatrophy of the face and other congenital

Fig. 188.—Congenital malformation of auricle and atresia of meatus.

deformities are not infrequently associated with microtia and meatal atresia. Hearing tests usually show the results obtained in lesions of the sound-conducting apparatus (p. 278) but even in bilateral cases, the human voice is, as a rule, heard well enough to allow the patient's speech to develop. Operation in unilateral cases is only called for when otitis media and mastoiditis are present on the affected side. In other unilateral cases the improvement in hearing is not sufficient to justify operation (Alexander). In bilateral cases operation is indicated only if deafness is marked and if radiographs and functional examination show that the labyrinth is healthy.

DEFORMITIES AND DISEASES OF THE AURICLE.

Outstanding Auricle.—At times patients make complaint of undue prominence of the auricle. In these cases a plastic operation may be performed as follows : A lozenge-shaped area of skin is removed from the posterior aspect of the auricle and from the mastoid process ; the raw surfaces are then brought into contact, and the edges of the skin are sutured (*Fig.* 189, *a*). In cases with more extreme displacement Ruttin's operation should be performed. The auricle is pressed against the side of the head, and a curved incision made in the mastoid region corresponding to the posterior limit of the auricular contact (*Fig.* 189, *b*, curved line D E F). This incision is parallel to the retro-auricular groove. A second curved incision is next made on the posterior surface of the auricle (*Fig.* 189, *b*, curved line A B C), and the crescentic flap is dissected forwards for a short distance. The upper extremities of the two curved incisions are now united by a horizontal cut, as are also the two lower ends, and the included skin and subcutaneous tissue are removed (*Fig.* 189, *c*). The auricular flap is now drawn backwards and united by stitches to the edge of the mastoid incision. The auricle is thus drawn back and it is kept in its new and improved position by dressings and a bandage until the wound has healed.
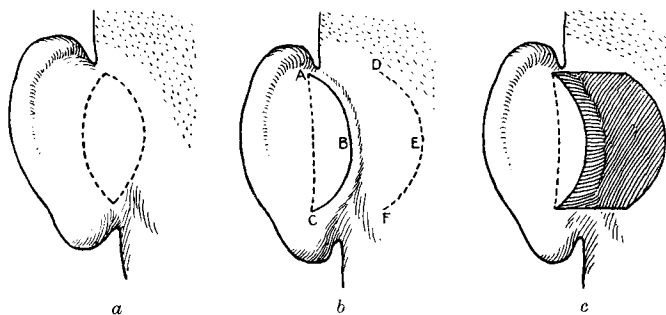
Fig. 189.—(*a*) Operation for outstanding auricle of moderate degree. The dotted lines show the lozenge-shaped area of skin to be removed. (*b*) and (*c*) Ruttin's operation for correction of extreme degree of outstanding auricle. See text.

Fistula Auris Congenita.—This is an opening which, when present, is usually found in front of the helix or tragus and leads to a fine blind canal. The orifice may become blocked, with the result that a fluctuating tumour forms. The fistula is the remains of the outer or lateral part of the first branchial cleft. Abscess formation may occur. Treatment consists in the excision of the fistula.

Hæmatoma Auris may result from injury ; for example, it is not uncommonly met with among boxers and Rugby football players. It may also occur in the case of insane persons and the aged. An effusion of blood occurs under the perichondrium and forms a swelling on the lateral or anterior surface of the auricle which may have a bluish tinge (*Fig.* 190). In traumatic cases considerable pain is experienced.

Suppuration may take place, resulting in destruction of cartilage, and finally in shrivelling of the auricle. If uncomplicated by inflammation, the serum becomes absorbed, but a certain amount of permanent thickening remains. When suppuration occurs the abscess should be opened and drained.

TREATMENT.—In the early stages, before coagulation of the blood has taken place, aspiration is often serviceable, but may have to be repeated, owing to further accumulation of blood. Krüger recommends painting with iodine, aspiration, moulding a thin layer of cotton-wool over the parts, and finally painting with collodion. If the patient is seen at a later stage, free incision and evacuation of the hæmatoma is probably the most satisfactory treatment. The clot is removed with a curette, and the incision closed except for a small opening which admits the end of a catheter connected to an evacuation pump which removes the accumulated blood. Sterile vaseline is applied over the auricle and adjacent skin. A mould, filled with plaster-of-Paris cream, is now placed over the ear and, as the plaster hardens, the catheter is gently withdrawn. The cast is removed by fragmentation with dental forceps in ten days (Palmer).

Perichondritis of the auricle may be due to a hæmatoma becoming infected with micro-organisms, or to the extension of an infection from a furuncle on the posterior meatal wall, but is most frequently seen after the radical mastoid operation. In post-operative cases the causal organism is usually the *B. pyocyaneus*, and the aural pus in such cases has frequently a green tinge. The condition

Fig. 190.—Hæmatoma of auricle.

manifests itself, as a rule, on the tenth day after operation : it is characterized by severe pain in the ear, accompanied by a rise of temperature ; the auricle rapidly becomes swollen and dusky in colour and its normal contour is lost, the swelling being apparent on both its surfaces. As the suppuration progresses, necrosis of the cartilage takes place, with the result that the auricle finally shrivels.

TREATMENT consists in early free incision and drainage and, when the cartilage is affected, it should be pierced, and a drain passed through the auricle from front to back. Ichthyol and distilled water in equal parts should be painted over the inflamed part, and the mastoid cavity should be swabbed out with a 2 per cent solution of silver nitrate.

Herpes Zoster Auricularis.—

Various skin diseases may affect the auricle. Their treatment must be carried out on general principles and will not be discussed here.

Malignant Disease of the Auricle.—This subject is dealt with in Chapter *XL.*

THE EXTERNAL MEATUS.

Furunculosis.—Furuncles may be found in the external acoustic meatus and may be restricted to this part, or be associated with boils in other parts of the body. They generally occur in debilitated persons and in diabetics, but are sometimes met with in healthy individuals. Furunculosis is due to the infection of hair follicles or sebaceous glands by staphylococci which may gain entrance from without as the result of scratching, or from within in a case of middle ear suppuration. The furuncle may develop in the superficial layers of the skin, or it may be more deeply seated. Several furuncles may be present at the same time, and there is a great tendency to recurrence.

SYMPTOMS.—Furuncles are associated with severe pain in the ear and, if there is sufficient swelling to occlude the meatus, deafness may also be present. In their superficial form they present a small, red, circumscribed and very tender swelling on the skin of the external meatus. When they are more deeply seated, the swelling is more diffuse and of the same colour as the rest of the meatus. When the boil is situated on the anterior or inferior wall of the cartilaginous meatus, movements of the jaw considerably aggravate the pain : swelling of the lower eyelid, if present, is characteristic of furunculosis in this position. (In the zygomatic type of mastoiditis (see p. 338) there is often swelling of the upper eyelid.) When the boils are situated on the posterior wall, close to the bony meatus, the auricle may become erect and œdema may appear over the mastoid process. If this is associated with discharge from the ear, it may be very difficult to decide whether the signs are due to the presence of a boil or to inflammation of the mastoid process. In making a differential diagnosis between furunculosis of the external meatus with cellulitis (and consequent swelling) in the retro-auricular groove on the one hand, and acute suppurative otitis media with mastoiditis on the other, the following points should receive attention : (1) A history of recent cold in the head or influenza is in favour of otitis media and mastoiditis, while a history of staphylococcal infection in some other part of the body is suggestive of furunculosis. (2) Careful otoscopic examination may reveal the presence of a boil on the posterior or superior meatal wall. As a rule, however, the walls of the meatus are so swollen that otoscopy gives little assistance. (3) The discharge in furunculosis is thick and scanty, while in otitis media it is more profuse and mucopurulent. (4) In furunculosis there is great pain on pulling the auricle and meatus, but in mastoiditis this pain is absent or less marked. (5) The hearing in the affected ear is better in furunculosis than in mastoiditis : in the latter the hearing distance for the conversation voice is as a rule reduced to three or four feet. When testing the hearing, it is useful to insert into the meatus past the swollen parts an aural speculum (infant size). If no otitis is present the hearing of the patient should be restored. (6) It is important to differentiate the points of tenderness peculiar to the presence of a furuncle. They are (a) over the tragus, (b) below and medial to the lobe of the ear, and (c) along the anterior border of the mastoid process. When mastoiditis requires to be differentiated, pressure

should be made along the posterior border of the mastoid bone and over the antrum, though this latter point can be common to both conditions. (7) If on puncturing the retro-auricular swelling with a hypodermic needle and syringe, pus is obtained on withdrawing the plunger almost immediately after the skin has been pierced, the case is one of furunculosis. If, on the other hand, the needle has to be pushed on till bone is reached before pus is withdrawn, the condition is one of mastoiditis. (8) In otitis media a whistling or bubbling sound may be produced if the patient performs Valsalva's experiment, thus pointing to the presence oi a perforation of the drumhead. (9) A good radiogram of the ear is of assistance if it shows the presence of well-developed air-cells on the affected side. It must not be forgotten that both furunculosis of the meatus and mastoiditis may be present at the same time. The differential diagnosis is often extremely difficult, and in such cases it is better to treat the condition as one of mastoiditis and to operate accordingly.

TREATMENT.—In the milder cases palliative measures may be adopted to relieve the pain. Aluminium acetate solution (8 per cent) on a wick of gauze, frequently gives relief : 10 per cent ichthyol in glycerin may also be employed on a strip of gauze and changed frequently. Noltenius advises dry heat applied by means of the Sollux lamp or by a half-watt electric lamp through an opening cut in a cardboard shield. If the pain is at all severe, relief will quickly be obtained by incising the furuncle deeply from within outwards with a tenotomy knife. General anæsthesia (ethyl chloride) should be used. For after-treatment, instillations of a solution of peroxide of hydrogen should be employed along with gentle syringing, in order to cleanse the meatus ; thereafter the canal should be gently packed with a strip of gauze soaked in one of the above solutions. When the boils have healed, an attempt must be made to sterilize the skin lining the meatus, in order to prevent recurrence. For this purpose instillations of a solution of corrosive sublimate in alcohol (1–2000) are to be recommended. If, in spite of every care, recurrence takes place, a vaccine (preferably autogenous) may be used with advantage. The general health must also be attended to. In recurring boils in the ear, rest in bed and tonic treatment are strongly advised, followed by a holiday.

Diffuse Inflammation of the Meatus.—This is generally secondary to suppuration in the middle ear, and may then be associated with the presence of the fusiform bacilli and spirochætæ of Vincent (Cheatle). In such cases the discharge is profuse and fœtid and the meatal walls and the periotic glands are swollen. The local application of a 10 per cent solution of sulph-arsphenamine is recommended. Otitis externa may also result from mechanical and chemical irritants. Occasionally diphtheria may attack the external ear ; it is characterized by the presence of a fibrinous exudate in the meatus. Erysipelas may also spread to this region, and, in syphilitic subjects, condylomata may be found which give rise to a very obstinate form of inflammation. Diffuse inflammation of the meatus is associated with a considerable degree of pain ; the meatus becomes narrowed owing to swelling of its walls and to the accumulation of surface epithelium and inflammatory exudate.

The drum membrane may be difficult to see, and there is frequently a moderate degree of pyrexia.

TREATMENT.—If the pain is severe, morphia may be administered. The ear should be gently syringed out and lightly packed with ¼ in. ribbon gauze soaked in 8 per cent solution of aluminium acetate or ichthyol 10 per cent in glycerin. Ilon abscess salve is extremely useful when incorporated in ribbon gauze packing. If relief is not thus obtained linear incisions may be made in the swollen meatal walls. During the chronic stage the meatus should be painted with a solution of crystal violet, ½ per cent in equal part of alcohol and distilled water.

Dermatitis or Seborrhœic Eczema.—Eczema may attack the meatus alone, or be associated with eczema of the auricle and scalp. As a rule the outer part of the canal is especially affected. The skin becomes dry and scaly, and occasionally fissures form near the meatus which becomes plugged with epithelial débris. There may be great narrowing of the external meatus. In some cases the eczema is due to chronic middle ear suppuration.

TREATMENT.—The ear should be kept clean by syringing, followed by dehydration with alcohol and careful drying. Though this treatment alone is sufficient in mild cases, local applications are often required. Many otologists employ a solution of silver nitrate in spirits of nitrous ether (15 gr. to 1 oz.), which is applied by a probe dressed with cotton-wool and dipped in the solution. The application of silver nitrate will probably have to be repeated several times; this should be done at intervals of a few days. Another useful remedy is an ointment containing salicylic acid (10 gr.), precipitated sulphur (10 gr.), and vaseline (1 oz.). This should be applied on strips of self-edge gauze inserted into the meatus by means of angled aural forceps. The scalp should be shampooed twice a week with soap spirit.

Otomycosis.—By this term is meant the presence of some fungus (usually an aspergillus) within the external meatus. The condition, which is very rare in this country, may cause deafness and itching. On inspection a greyish or brownish-black mass is observed in the deeper part of the meatus. Deafness only may be complained of, but itching and pain may also be present. On inspection of the ear, the meatus may be filled with a mass resembling wet newspaper (McBride); in other cases it presents a brownish-black appearance due to the presence of the *Aspergillus niger*. When the mass has been removed by syringing, it rapidly re-forms. This is enough to suggest otomycosis, but a definite diagnosis can only be made by means of the microscope which will reveal mycelium spores and perhaps spore-bearing stalks.

TREATMENT consists in syringing the ear and the instillation of corrosive sublimate in alcohol.

Impacted Wax.—Wax is secreted from the ceruminous glands situated in the outer part of the meatus, and numerous sebaceous glands are also present in this region. As a rule the secretion from these glands is sufficiently fluid to find its way down to the external orifice, and here it is removed at each washing. Various factors may tend to the accumulation of wax within the meatus, such as undue narrowness of the passage,

the presence of seborrhœic dermatitis of the meatus, excessive or abnormally thick secretion, and the presence of a foreign body or meatal exostosis. It is often found that persons who are liable to accumulations of wax have acquired the habit of inserting the end of a towel into the meatus after washing, thus pushing in the wax which forms in the outer part of the passage, and which is normally thrown off in imperceptible flakes or washed away in the daily ablutions.

SYMPTOMS.—A considerable plug of wax may be present in the ear without producing any symptoms so long as a chink exists which allows of sounds passing to the ear. When the blocking becomes absolute, deafness results; this often occurs with striking suddenness and is usually due to water finding its way into the ear. Tinnitus and pain may also be present and, when the wax presses against the membrane, vertigo may be complained of.

DIAGNOSIS.—The diagnosis is generally easy. A mass is seen in the meatus obviously nearer the eye than the drum membrane; it may be coal-black and glistening, but is usually of a yellow or brown tinge. If mixed with cast-off epidermis the mass may present a greyish colour. When in doubt as to what he is looking at, the observer should syringe the ear.

PROGNOSIS.—The prognosis must be guarded, as the expulsion of the wax does not always improve the hearing. There may, in addition, be some other cause of deafness in the middle or inner ear.

TREATMENT.—The treatment is generally simple. The ear is syringed with a lukewarm solution of bicarbonate of soda until the plug comes away. When the wax is hard, considerable difficulty may be experienced in removing it; in such cases, especially if pain is produced, a solution of bicarbonate of soda (see Appendix) should be instilled several times before syringing; liquid paraffin or a solution of peroxide of hydrogen (10 vol.) may be used for the same purpose. When the ear is being syringed, the surgeon should inspect it from time to time, so that he may not continue the syringing after all the wax has been removed.

Keratosis Obturans.—The meatus occasionally becomes blocked by masses of epithelium, which form hard plugs and generally contain a certain amount of wax. Considerable difficulty is usually experienced in removing the plug, as it is closely attached to the meatal walls; this should be accomplished if possible by syringing after softening with one of the above solutions. Occasionally so much pain is caused by attempts at removal by syringing that a general anæsthetic has to be given. After the removal of the mass the meatus is often found to be considerably enlarged by the long-continued pressure. In order to prevent recurrence the meatal walls should be coated frequently with the sulphur-salicylic vaseline mentioned above (p. 318).

Foreign Bodies in the Ear.—Foreign bodies, both animate and inanimate, may be found in the ear. The latter are much more frequently met with and, in the case of children, are often introduced by the patients themselves. Inanimate objects may be divided into those which swell with moisture, such as peas and beans, and those

which do not swell, such as beads, buttons, or shells. Foreign bodies rarely cause any trouble of themselves unless the tympanic membrane has been injured ; indeed, they may remain in the ear for years without producing the least disturbance. It is to ill-directed attempts at removal that most of the disasters which have occurred in these cases must be attributed. In this way membranes have been ruptured and ossicles removed, purulent inflammation of the middle ear, the inner ear and the meninges has been set up, and in some cases death has resulted, even when no foreign body has been present. It is accordingly of the utmost importance, when a patient comes with a history of a foreign body in the ear, that the practitioner should assure himself of its presence by careful inspection. If it is not seen, the ear may be gently syringed, as a very small body may be out of sight on the floor of the meatus, beyond the isthmus and close to the membrane. If the foreign body is detected, an attempt should be made in the first instance to remove it by syringing. The stream should be directed along that part of the wall of the meatus where there is the widest space between it and the foreign body.

While the removal of a foreign body is usually effected with ease when it has not been driven in by ill-directed interference, great difficulties may be presented in cases of impaction, when the object has become much swollen from absorption of fluid, or when the meatal walls have become inflamed ; in such circumstances the practitioner will be well advised to call in a specialist. In cases of impaction it is sometimes possible to withdraw the foreign body by means of a fine hook or bent probe or scissor-handled angled forceps passed between it and the meatal wall. As patients suffering from foreign body in the ear are usually young children who have often been frightened by inexpert attempts to help them, it is usually necessary to give a general anæsthetic, such as ethyl chloride. If the walls of the meatus are swollen and bleeding, it is advisable, before operating, to insert a strip of half-inch-wide self-edge gauze soaked in a 10 per cent cocaine solution to which a few drops of adrenalin have been added. When diffuse inflammation of the meatus has been set up by attempts at removal, it is best to use palliative measures and to wait until the inflammation has subsided, before taking further steps to extract the foreign body. In rare instances, especially when the object has been driven into the middle ear, an external operation is required for its removal. An incision is made down to the bone close to the attachment of the auricle which is then turned forward. The posterior margin of the meatus is exposed, and if necessary a portion of the posterior bony meatal wall is removed with hammer and gouge ; the membranous meatus is incised horizontally, and the foreign body extracted with a hook or forceps.

Animate foreign bodies in the external meatus are rarely met with in Great Britain. Flies in the ear cause intense pain and should be killed by chloroform vapour before removal. In South Africa cases have been recorded in which the spinous ear-tick has invaded the external meatus.

Atresia and Narrowing of the Meatus.—It has already been stated that atresia of the meatus may be a congenital deformity associated with

malformation of the auricle (*see Fig.* 188). Marked narrowing of the passage, and even complete occlusion, are also sometimes met with in cases of chronic middle ear suppuration and in chronic eczema. The narrowing may be a simple diminution in the calibre of the meatus, due to thickening of the walls from their being constantly bathed in pus. In other cases complete occlusion may result from the formation of granulations on the walls of the meatus. Chronic eczema is another condition often associated with narrowing of the meatus. Injuries to the meatus are sometimes followed by the formation of membranes which occlude the passage. In old age the external orifice of the meatus is occasionally reduced to a narrow slit which, while not in itself a cause of deafness, leads to impairment of hearing when a relatively small amount of cerumen has accumulated.

TREATMENT.—Stenosis due to chronic eczema may be treated by the introduction of gauze strips smeared with sulphur-salicylic vaseline or by tents. In narrowing due to chronic middle ear suppuration a radical mastoid operation may be called for if the treatment of the causal condition does not relieve the stenosis ; this is especially indicated where there is evidence of retention of pus. If the narrowed passage be blocked by wax, this must be diagnosed and removed.

TUMOURS OF THE MEATUS.

Exostoses are the variety of tumour most commonly met with in the meatus. They may be single or multiple, pedunculated or sessile. When the base of the tumour is flat, it is usual to apply the term *hyperostosis* to the condition.

ETIOLOGY.—This is somewhat obscure. Sea-bathing and diving undoubtedly give rise to the condition, and it is also more frequently met with in gouty subjects. Exostoses occasionally develop in cases of long-continued middle ear suppuration.

APPEARANCES.—A single exostosis is less common than the multiple variety. It is usually attached to the posterior wall of the meatus, and appears as a smooth rounded body which may completely fill the passage. Multiple exostoses are frequently bilateral and symmetrical ; they may spring from the anterior and posterior meatal walls, and a small one is occasionally seen on either side of Shrapnell's membrane. The growths may almost entirely hide the membrane, but complete occlusion of the meatus is unusual in the multiple variety.

SYMPTOMS.—Exostoses do not cause symptoms unless the lumen of the meatus is completely obliterated ; but if this occurs, either by swelling of the covering of the exostosis or by the accumulation of wax, deafness is complained of. When there is retention of pus in a case associated with middle ear suppuration, severe symptoms will result. Occasionally the surface of the exostosis becomes slightly inflamed and causes much itching in the ear.

DIAGNOSIS.—As a rule the diagnosis is obvious on inspection ; but if there is any doubt, it can be cleared up by touching the growth with a probe, when its bony consistence will at once become manifest.

TREATMENT.—If exostoses are small and do not cause symptoms, no treatment is required ; but if large and producing occasional attacks of deafness, the treatment depends on whether the condition is complicated by the presence of middle ear suppuration. In such cases, if there is a single large exostosis filling the meatus, it is wiser to remove it, but some caution should be exercised in giving a prognosis as to the hearing. It may be found at operation that in addition to the exostosis there is marked narrowing of the meatus due to a generalized bony overgrowth. After a retro-auricular incision has been made and the auricle and membranous meatus detached it may be a matter of considerable difficulty to find the external bony meatus, the lumen of which may be reduced to that of a bony semicircular canal. In the multiple variety, operation should be avoided unless really necessary, as in this form complete obliteration of the meatus rarely occurs, and it may be very difficult to remove the tumours without damaging the membrane. A single exostosis may sometimes be removed through the meatus, local anæsthesia being induced by Neumann's method, but in the multiple variety an external retro-auricular operation is always preferable.

Cartilaginous tumours, fibromata, and papillomata have occasionally been found growing from the meatus.

Malignant Disease.—(*See* Chapter XL.)

TRAUMATIC RUPTURE OF THE TYMPANIC MEMBRANE.

Rupture of the membrane may be caused accidentally by a knitting-needle, hair-pin, or some similar object. The history usually given is that the patient has been scratching the ear with one of the above implements and that the hand or the instrument has slipped, with the result that the membrane has been perforated. Similar accidents have occurred through twigs entering the ear when the patient has been passing through a thick wood. Ruptures may also be produced by a box on the ear. Parents frequently state that this was the cause of otorrhœa in a child, and that the school-teacher is to blame. Such statements should be accepted with reserve, because examination of the other ear frequently shows a scar or chalk patch in the drumhead, sure evidence of a past attack or attacks of otitis media. It is difficult to believe that the teacher has boxed both ears of the child and that bilateral otitis media has resulted. Ruptures of the drumhead may be caused by inflation of the ear by the air-douche, when the membrane will usually be found to be either cicatrized or atrophied. Rupture may also follow unskilful attempts to remove foreign bodies, and even a kiss on the ear. It is also met with in fractures of the base of the skull : in such cases the tympanic cavity is filled with blood (hæmato-tympanum). An explosion—e.g., high-explosive shell injury—may shatter the drumhead and seriously injure the labyrinth (*see* INJURY OF THE LABYRINTH, p. 413). Too forceful syringing has occasionally been the cause of rupture of the tympanic membrane, but it will generally be found in these cases that a pre-existing scar has been present and has given way under the stress.

SYMPTOMS.—At the moment of rupture, severe pain is felt, usually

accompanied by loud tinnitus, and occasionally by faintness, vertigo, and nausea. When the shock of rupture has passed, the patient finds that his hearing is more or less impaired. If the labyrinth has not been affected, the deafness may be very slight; but if this is involved to any extent, the deafness is usually very marked and may be permanent.

APPEARANCES.—A perforation caused by direct violence is generally found in the inferior part of the membrane and may be of varying size and shape, while the edges may be irregular or ragged, the appearances depending on the nature of the body which made the perforation. When it is due to indirect violence, the perforation is usually slit-like or oval, and is found in the anterior half of the membrane. The edges of the perforation in both cases are of a red colour from extravasation of blood and, if the perforation is of any size, the pale glistening mucous lining of the promontory can be seen through it.

PROGNOSIS as regards the hearing depends largely on whether the labyrinth is affected or not ; this point may be determined by the tuning-fork tests. If suppuration ensues, permanent impairment of the hearing may result ; the case then passes into the category of acute middle ear suppuration and must be treated as such.

TREATMENT.—Much harm can be done by injudicious treatment in these cases, and nothing can be worse than to resort to active measures, such as the instillation of drops, or syringing the ear ; accordingly, if the practitioner is fortunate enough to see the patient before any treatment has been adopted, he should confine himself to painting the perforation with weak tincture of iodine and placing a plug of cotton-wool in the ear and should warn the patient of the danger of allowing fluids to enter the meatus. Alcohol and tobacco must be interdicted. It is advisable to inspect the ear from time to time, so that, should any unfavourable sign arise, it may be detected. In a favourable case the perforation will heal, the symptoms will disappear and the hearing will return to normal.

MYRINGITIS.

During certain epidemics of influenza the disease shows a predilection to attack the ear. The patient complains of severe earache, and on inspection blood blisters of a reddish-brown or purple colour can usually be seen on the walls of the meatus, close to the annulus and on the drumhead itself (myringitis bullosa). The bullæ are prone to spontaneous rupture, with blood-stained discharge from the ear. The infective organism is a hæmolytic streptococcus. Milligan held that these blood blisters may occur quite independently of any middle ear lesion, and Jenkins points out that in such cases the hearing is practically normal. In the great majority of cases, however, the bullæ are associated with an otitis media, for, as Tweedie points out, the subperiosteal space of the posterior meatal wall is in anatomical continuation with the submucous space of the tympanum. Sagging of the meatal wall in acute middle ear suppuration, and Neumann's method of local anæsthesia, both depend on this fact.

TREATMENT consists in incising the bullæ under ethyl chloride anæsthesia and inserting a strip of sterile gauze.

CHAPTER XXXVI.

ACUTE OTITIS MEDIA AND MASTOIDITIS.

ACUTE SALPINGITIS.

ACUTE salpingitis, or inflammation of the lining membrane of the auditory (Eustachian) tube, is not infrequently caused by attacks of acute nasal catarrh. It is associated with pain radiating to the ear, slight deafness and a feeling of 'stuffiness' in the ear. Low-pitched tinnitus with 'popping' or 'cracking' noises may be complained of. On otoscopic examination the drumhead is usually normal, but it may be slightly injected. , Posterior rhinoscopy or the use of the nasopharyngoscope shows that the pharyngeal orifice of the tube is red, glazed and swollen.

TREATMENT is that of the catarrhal rhinitis which causes the trouble. In addition, the orifice of the tube may be painted with a 1 per cent solution of silver nitrate, or 10 per cent argyrol, by means of a cotton-tipped probe curved like a Eustachian catheter and passed through the corresponding nasal cavity, which should be previously cocainized. If the drumheads show congestion, and pain is present, drops of carbolic acid (6 gr.) in glycerin (2 drachms) should be instilled into the external meatus as described under acute purulent otitis media (p. 330).

ACUTE NON-SUPPURATIVE OTITIS MEDIA.
(Seromucous Middle Ear Catarrh : Acute Catarrhal Otitis Media.)

Acute middle ear catarrh is produced by the extension of a catarrhal inflammation of the nasopharynx along the auditory (Eustachian) tube to the tympanum ; hence it is commonly met with in children suffering from adenoid vegetations, and may occur in an ordinary cold in the head. It is also found in cases of new growths of the nasopharynx which press on the mouth of the Eustachian tube, and in diphtheritic paralysis of the soft palate. In the last two conditions there is merely a transudation of serous fluid which is free from bacteria (hydrops ex vacuo). The inflammation in most cases extends to the whole of the middle ear cleft ; it may, however, be limited to the lower or anterior end of the Eustachian tube which becomes temporarily blocked—Eustachian obstruction. The fluid exuded may be either watery or viscid.

SYMPTOMS.—The condition is not usually associated with much pain, though this symptom is sometimes met with, especially in children. When pain occurs it is sometimes only present at night and in any case is then worse. There is generally a sense of fullness or numbness in the head, and the patient often complains that he feels stupid and as if there were water in his ear. Deafness may be very marked, but in some cases

it is hardly noticeable.   The degree of deafness depends largely on the amount of exudation, and it may be subject to great variations.   Sudden and marked improvement sometimes occurs after the ear is felt to 'crack', due to momentary separation of the sticky walls of the auditory (Eustachian) tube and the entrance of air into the tympanum.   It is also influenced by the state of the weather, being worse on damp foggy days than in a dry atmosphere.   Autophony, or an undue resonance of the patient's voice in his own ear, is sometimes present and may cause great discomfort.   Tinnitus is generally present and may continue after the other symptoms have subsided, but its persistence is usually an unfavourable sign.   In bilateral cases in children, due to the presence of adenoid vegetations, there is often a disability to concentrate the attention (Guye's aprosexia).

APPEARANCES.—The drum-membrane presents varying appearances. When there is merely *Eustachian obstruction*, it may show but little change from the normal ; there is generally, however, some degree of indrawing of the handle of the malleus (*Plate XVI*, 2, p. 304), with slight projection of its short process, and the membrane may be congested. When the process involves the tympanum it is accompanied by exudation (*seromucous or secretory middle ear catarrh*) ; the appearances depend on the amount and character of fluid present and on the transparency of the membrane.   The condition is most difficult to detect when the tympanum is full of fluid ; the membrane then has a distinctly yellow tinge and also a peculiar glistening appearance as if a drop of oil had spread itself over the surface ; the handle of the malleus, and frequently the long process of the incus, are usually clearly defined.   The appearances are much more readily recognized when the fluid does not fill the tympanum ; its upper limit then appears as a hair-like line running across the drum-membrane (*Plate XVI*, 3); this line is concave or convex owing to capillary action.   The membrane below the line appears yellow, while above it has a grey tinge.   Occasionally, bubbles are seen behind the drum-membrane ; these are produced by the presence of air in the fluid, and may be noticed immediately after inflation when the exudate has been only partially expelled.   The air douche when heard through an auscultation tube is quite characteristic, according to Mollison.   The sound produced is that of fluid and instead of the normal continuous blowing sound it is interrupted and similar to the interrupted sound of 'cogwheel' respiration obtained on auscultation.   An even more marked change is produced by the air douche if the fluid is completely dispersed ; the whole membrane then becomes grey and loses its glistening moist appearance.   The changes described above cannot be detected if the membrane is thickened ; the presence of fluid in such cases can be inferred by the effects of inflation, but can be demonstrated only by paracentesis.

In more severe cases—*catarrhal otitis media*—the exudation into the tympanic cavity is so copious that the drumhead becomes slightly bulged outwards toward the meatus.   Further, there are a certain number of pus-cells in the exudate, giving it a mucopurulent character.   The vessels of the drumhead radiating from the malleus are markedly dilated and appear as red wavy lines on a greyish surface.   These appearances

are shown in *Plate XVI*, 4. The condition is really an intermediate one between seromucous catarrh and acute purulent otitis media, and is associated with earache and a considerable degree of deafness.

Proetz holds that certain cases of non-suppurative otitis media are due to allergy. The symptoms are pain, tinnitus and deafness affecting one or both ears coming on suddenly after exposure to, or ingestion of, some foreign protein to which the patient is sensitized. The drumhead is congested and bulging or covered by a layer of desquamated epithelium. As a rule there is no fever. The diagnosis is made upon the allergic history of the patient, e.g., attacks of asthma. Paracentesis is not indicated as the condition subsides when the allergic crisis is relieved. It must be admitted, however, that it is difficult to draw the line in allergic individuals between allergic and infectious otitis media.

DIAGNOSIS.—The diagnosis of acute catarrh of the middle ear is easily made by one who can recognize the otoscopic appearances described above; it must be admitted, however, that the beginner usually fails to detect these rather delicate changes, but in most cases he can form a correct diagnosis from the results of the tuning-fork tests, and from the effects of inflation on the hearing. The tuning-fork tests point to an affection of the sound-conducting apparatus; Rinné's test is negative, bone-conduction is lengthened, and on applying Weber's test the sound is referred to the affected ear. The lowest tones are not heard by air-conduction, while the highest notes are retained. In uncomplicated cases the effects of successful inflation are most striking; the fluid in the tympanum is dispersed, and the pressure within the tympanum is equalized to the atmospheric pressure, with the result that the hearing is at once restored. A similar effect is produced in cases of Eustachian obstruction in which there is no exudation into the middle ear. During inflation the observer's ear should be connected with that of the patient by an auscultating tube, when in the presence of fluid a moist sound may usually be heard.

PROGNOSIS.—The prognosis is good in recent cases and in those due to the presence of adenoid vegetations; but there is a great tendency to recurrence when the causal condition cannot be cured, and on each occasion the condition is more resistant to treatment. The prognosis is less favourable when the air-douche does not cause a marked improvement in the hearing, while in cases which recur frequently, changes take place in the middle ear which may result in permanent impairment of hearing (chronic adhesive process).

TREATMENT.—The first step is to get rid of the fluid in the tympanum, and the most satisfactory method of doing this is inflation of the ear by Politzer's method. Ruttin points out that inflation must not be too violent as otherwise nystagmus and giddiness may be produced. The inflation must be repeated every second day until the exudate ceases to reappear. In addition to the politzerization, the mastoid process may be massaged for five minutes once or twice daily. The value of massage is doubtful, but at least it gives the patient something to do. The massage should be carried out from above downwards, ending at the angle of the lower jaw. The skin is lubricated with a little vaseline to prevent

irritation. Another method is to cocainize the nose and pass a Eustachian tube catheter. A Weber-Liel tube is then inserted into the catheter and passed up the Eustachian tube into the middle ear cleft. Suction is then employed to withdraw the catarrhal exudate. If the fluid cannot be dispersed by politzerization, combined with massage, or the application of small fly-blisters (the size of a sixpence) in front of, below, and behind the ear, or if after a week the exudate is not diminishing, the membrane should be incised with very careful aseptic precautions (*see* p. 331). The importance of the strictest asepsis cannot be exaggerated, for the slightest carelessness may result in the case becoming one of acute suppurative otitis media. In non-suppurative cases in adults, paracentesis may be performed with the aid of local anæsthesia obtained by means of Blegvad's drops (APPENDIX, p. 443). After paracentesis, politzerization should immediately be undertaken in order to drive the fluid from the tympanum, and when this is very viscid and cannot be completely expelled, suction may also be employed by means of Siegle's speculum or Sondermann's apparatus. The fluid which has been driven into the meatus should be mopped up with sterile wool or a strip of sterile gauze, and a pledget of wool should be worn in the ear. There is a great tendency for the perforation to close, and to obviate this the patient should perform Valsalva's experiment three or four times a day, while politzerization should be practised daily and the mastoid process massaged, as described above, until the fluid ceases to accumulate. When the perforation heals too soon, in spite of these precautions, a second incision should be made. If a cure is not effected after a month, politzerization must be discontinued for at least two weeks. The causal condition in the nose or nasopharynx should receive appropriate treatment and, if an operation for the removal of adenoid vegetations is necessary, it should on no account be postponed.

ACUTE PURULENT OTITIS MEDIA.

Acute purulent inflammation of the middle ear may be divided clinically into a mild form in which perforation does not occur—*otitis media acuta simplex*—and a more severe form associated with perforation—*otitis media acuta perforativa*.

ETIOLOGY.—Acute middle ear inflammation may result from any inflammatory condition of the upper air-passages ; hence it is a very common sequela of the exanthemata, especially measles and scarlet fever ; it also occurs frequently in acute catarrhal rhinitis (coryza), and in influenza, whooping-cough and diphtheria. It may be caused by too vigorous syringing of the nose, and by operations on the nasal cavities and the nasopharynx. Packing the nose or plugging the nasopharynx in severe cases of epistaxis may give rise to acute middle ear suppuration especially if the plugs are left in for more than twenty-four hours. Otitis media may also result from bathing in the sea or public baths, during which water may enter the nose and pharynx and so infect the Eustachian tube and tympanic cavity. (Bathers who get water into the nose or nasopharynx should not blow the nose violently, but should allow the

water to run out. Violent blowing of the nose acts like Valsalva's inflation and drives the fluid, which may be septic, into the middle ear cleft.) A second route of infection in cases of otitis media is via the external meatus following injuries of the drumhead. Fractures of the skull involving the temporal bone are sometimes followed by otitis media —the infection coming either by way of the ruptured drumhead or through the Eustachian tube. Lastly, in rare cases otitis media may follow suppuration in the labyrinth resulting from epidemic cerebrospinal meningitis. In this case the middle ear is infected by the purulent exudate in the labyrinth invading the middle ear through the oval or round window.

The chief predisposing causes are the presence of adenoid vegetations in the nasopharynx, and an hereditary disposition to catarrhal and suppurative affections of the upper air-tract, including the middle ear cleft. The presence of an old perforation of the drumhead predisposes to recurrence of acute otitis media if the patient suffers from an acute attack of nasal or pharyngeal catarrh.

BACTERIOLOGY.—One or other variety of streptococcus has been shown to be the most common cause of acute middle ear suppuration, a hæmolytic streptococcus being the causal organism in many cases, especially in those associated with influenza. Various forms of the pneumococcus are also frequently met with. The *Staphylococcus pyogenes aureus* and *albus* and mixed infections are more rarely found.

SYMPTOMS.—At the onset of an attack, pain is the chief symptom ; it is usually worse at night and is at first confined to the depths of the ear, but soon radiates over the side of the head, forwards towards the temple, and backwards towards the occiput. It is intensified by actions, such as yawning or sneezing which tend to increase the intratympanic pressure. In the more severe forms the pain may be almost unbearable, but it is generally much relieved when perforation of the membrane occurs ; in influenzal cases associated with intense earache, the pain may remain unabated for some days after rupture of the membrane. In most cases, in addition to the pain, there is some degree of tenderness on pressure over the mastoid process. It will be remembered that the antrum is part of the middle ear cleft, and accordingly, if there is pus in the tympanum, it will probably also be found in the antrum ; hence this symptom does not necessarily mean that the bone of the mastoid process is involved in the inflammation ; the evidence of this complication will be discussed later, but it may be stated here that the surgeon should make a daily examination of the mastoid process by pressing with his finger (1) over the antrum, (2) over the posterior border, and (3) over the tip of the process. 'Early' mastoid tenderness during the first few days of the illness is not of serious import, as it passes off as a rule soon after the discharge is established. Alexander has called this early tenderness 'mastoidism'. Recurrent or 'late' tenderness indicates that the mastoid is seriously involved, and forms one indication for the Schwartze operation.

In adults, fever (temperature of over 100° F.) is usually absent but in young children at the onset of the attack there is often a sharp rise

to 102° or 103° F. Acute otitis media is the most frequently overlooked affection of infancy and childhood (Emerson). The child may not complain of earache, though it may repeatedly put its hand to its ear or bore its ear into the pillow, or else suddenly wake up and scream with pain. In some cases symptoms strongly suggestive of meningitis may be present, e.g., vomiting, convulsions, positive Kernig and Babinski signs. On lumbar puncture, however, the cerebrospinal fluid is normal, and after paracentesis the alarming symptoms, called by Alexander 'meningism', at once pass off. The diagnosis, however, is made by examination of the drumhead. If paracentesis is performed promptly, the symptoms usually subside in twenty-four hours. (In order to prevent otitis media in children suffering from infectious diseases, Emerson recommends that a few drops of a 10 per cent solution of argyrol should be introduced into each nostril three times a day.) In adults the presence of headache, especially frontal headache, during the course of an otitis media is a grave symptom and probably indicates meningitis.

In the early stages there is only slight impairment of hearing, but in a day or two deafness becomes much more marked. Tinnitus is also generally complained of and is in most cases of a throbbing character, due to the pulsation of the dilated vessels in the tympanum. Vertigo is not a common symptom in acute inflammation. Facial paralysis occurs in a small percentage of cases.

APPEARANCES.—In a mild case, the first changes to be noted in the membrane are injection of the handle of the malleus and the appearance of fine vessels running from the umbo to the periphery, that is, a radial injection of vessels (*Plate XVI*, 4, p. 304). The affection may stop at this stage, the tympanic membrane and cavity gradually returning to normal. If the inflammatory condition progresses, the membrane loses its polish, the hyperæmia becomes general and the membrane bulges (*Plate XVI*, 6). The bulging is at first only to be observed in the posterior half of the membrane ; the hammer handle can still be distinguished and the anterior half of the membrane, which lies more in shadow, has a bluish tinge. If the inflammation does not subside at this stage, it passes into the more severe form in which perforation is almost inevitable. The whole membrane becomes very red and convex and the hammer handle can no longer be recognized. At one point, usually in the posterior half of the membrane, a yellow spot appears which, on careful examination, is often seen to pulsate ; it is here that the membrane will give way. In some instances a nipple-shaped projection, surmounted by a yellow spot, appears on the membrane. In severe cases associated with an attack of influenza, hæmorrhagic bullæ may develop on the surface of the membrane and on the meatal walls (*Plate XVI*, 5) ; in course of time these burst and discharge their contents into the meatus. In many cases the patient is not seen till the epithelium on the lateral surface of the drumhead has desquamated, so that on otoscopic examination all that the observer sees is a white mass of cast-off, sodden epithelial flakes. Before the true appearance of the drumhead can be observed, the ear must be syringed gently with a luke-warm

solution of boric acid and the meatus dried out with cotton mops. In the more severe cases and especially in influenza epistaxis is a prominent feature.

Appearances after Rupture of the Membrane.—In the first few days after rupture it is generally necessary to syringe the ear in order to obtain a view of the drumhead, as the discharge of pus is abundant. The perforation may be so small as to escape detection by the eye ; but if the inspection of the membrane is continued for a short time, its position will be indicated by the appearance of a bead of pus which reflects the examination light thrown from the mirror and will be seen to pulsate vigorously.

The discharge, at first abundant, gradually diminishes, and in favourable cases ceases after a period varying from a few days to two or three weeks. It may, if untreated, continue indefinitely ; the condition then passes into the category of chronic middle ear suppuration.

PROGNOSIS.—The prognosis in the majority of cases is good, both as regards the cessation of discharge and the return of hearing ; in mild cases without perforation complete recovery may confidently be expected. When perforation has occurred the outlook is not so favourable, particularly in those cases which arise in the course of the exanthemata, and which are especially liable to result in chronic otorrhœa associated with permanent impairment of the hearing. Mastoid tenderness should pass off completely within three days after the discharge from the ear has been established. Otorrhœa should cease in from seven to twenty-one days. In 80 per cent of cases the hearing returns to normal, and the drumhead may show slight opacity or a small scar at the site of the former perforation but sometimes there is no trace of the former inflammatory trouble. In other cases, though the discharge ceases, a dry perforation is left, and the hearing remains affected to some degree. In a small percentage, complications arise which may prove fatal (*see* Chapter XXXVIII).

TREATMENT.—In mild cases the patient should be confined to the house and, if a child, should be kept in bed. The bowels should be cleared out by a dose of calomel at night, followed by a saline aperient in the morning. The pain in the ear may be relieved by the instillation of a few drops of glycerin of carbolic acid with cocaine (*see* Appendix). Morphia may have to be administered for the intense pain. The instillation may be repeated four-hourly if necessary. The application of dry heat—e.g., a half-filled rubber hot-water bottle covered by flannel or a hot salt bag —is also of service in most cases, but poultices should be avoided. When the inflammation has subsided, the patient should undergo a course of inflation, either with the catheter or by Politzer's method ; this will hasten the return of the hearing.

In severe cases of inflammation, where it is believed that perforation is certain to occur, paracentesis should be performed. In deciding on this step, the surgeon must be guided partly by the appearance of the drumhead and partly by the symptoms. If, in spite of all palliative measures, the pain continues sufficiently severe to rob the patient of his sleep for one night, paracentesis should certainly be

performed ; but when the appearance of the drumhead from the first indicates a severe form of inflammation the procedure should be carried out without delay. The incision causes extreme though momentary agony, so that it is desirable to employ a general anæsthetic : ethyl chloride will be found very serviceable. Paracentesis must be performed with due regard to cleanliness ; the speculum and knife must be sterilized, and the external meatus cleansed by the application of biniodide of mercury in spirit or of tincture of iodine. The incision is made in the most bulging part of the membrane ; it should be more than a puncture, and its direction should be from above and behind downwards and forwards (*Fig.* 191). The whole thickness of the membrane should be divided. Beginners generally make the mistake of scratching the posterior meatal wall close to the drum-membrane, or else they make a superficial scratch on the membrane and do not divide

it. Paracentesis in the early stages only evacuates blood-stained serum, sometimes combined with bubbles of air under pressure ; later on it is followed by a discharge of pus which soon becomes abundant, and immediate relief from pain is experienced. Many surgeons when performing paracentesis make a culture from the discharge in order to obtain a vaccine, which may be of use if the purulent otitis media does not cease within the normal
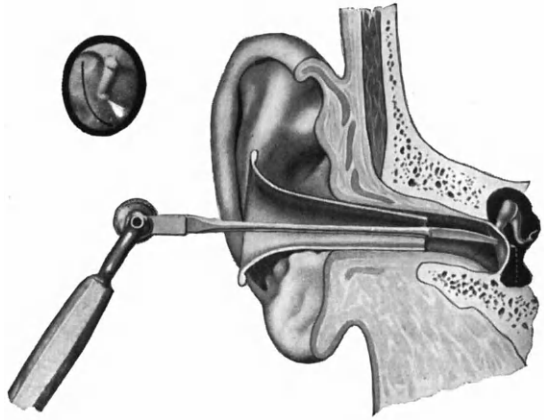
Fig. 191.—Incision of the drumhead (paracentesis). The small figure shows the extent and direction of the incision.

period. When the ear begins to discharge, whether as a result of paracentesis or of a natural perforation, one of two methods of treatment may be employed : (1) The dry method, where a piece of sterilized ribbon-gauze (one-half inch wide) is inserted into the external meatus by means of a pair of sterilized aural forceps. The gauze strip must be changed as often as it becomes saturated with discharge. This method is most suitable in hospital or in private cases where a trained nurse is available. (2) Recourse may be had to syringing, for which purpose warm boracic lotion or sterile saline solution may be employed. The amount of discharge must determine how frequently the syringing should be repeated ; it may be necessary every two hours. The ear should always be dried after syringing, and a piece of cotton-wool must be placed in the concha ; the meatus should not be tightly plugged. The syringing of the ear by the ordinary method should be continued until the discharge has entirely ceased, but at longer intervals as it diminishes.

Vaccine therapy is often of value in cases which are subacute and threaten to become chronic. The external meatus is syringed with sterile saline solution and dried with cotton mops. A pledget of cotton saturated with absolute alcohol is then inserted and left in position for five minutes. If the perforation be large, a sterile platinum loop is now introduced into the tympanum and the secretion at once transferred to blood-ascitic-agar plates. If the perforation is small, the pneumatic speculum is used to suck out the pus (Haskin). As an alternative, swabs may be taken through a sterile nasal speculum from the nasopharynx and also by passing a curved swab stick through the mouth and into the nasopharynx. Tanaka finds vaccine therapy very effective in the purulent otitis media of infancy. When operating on a case of acute mastoiditis it is a good plan for the surgeon to take a swab of the pus in the cavity and have a vaccine prepared in case there is delay in the cessation of the aural discharge or in the healing of the wound.

In cases where copious discharge persists for a period of four weeks, where deafness is marked, and the perforation is small, it is advisable not to delay draining through the mastoid bone, as this operation gives the best chance of restoring the hearing and at the same time obviates the risks of intracranial complications. If in addition to the above symptoms there is occasional diminution of discharge, accompanied by discomfort or pain, the indications become more pronounced. Many otologists, such as Heath and McKenzie, are in favour of the mastoid operation in the early days of middle ear suppuration, even in the absence of fever, mastoid swelling, or where pain is unrelieved by paracentesis. Our view, however, is that, in the absence of the symptoms of danger, the case should be watched for three or four weeks before operation is performed. Cases which are operated on too early, i.e., before active immunity has been attained, do not make such a satisfactory recovery as those which are dealt with at a later stage.

Systematic inflation of the ear should be carried out if the hearing does not improve rapidly as soon as the swelling of the membrane has subsided.

In all cases complicated by the presence of adenoid vegetations in the nasopharynx, removal of these growths is called for as soon as the acute symptoms have passed off. Then should aural discharge persist, the nasal sinuses should be thoroughly overhauled, as in our experience, the maxillary antrum on the side corresponding to the affected ear often shares in the original initial infection. An X ray in addition to a careful clinical examination of the nose and paranasal sinuses should therefore be carried out.

It is very necessary to ensure complete cessation of the discharge in all cases of acute suppurative otitis media ; otherwise the condition will pass into the stage of chronic otorrhœa, with all its attendant disabilities. In Berlin the arc-light is used in the treatment of cases which do not heal in the usual time. It is essential that the medical man in charge of the case, or the specialist, should satisfy himself by direct observation that the middle ear cleft is dry, and that he should not rely on the statement of the patient or his friends as to this point. If,

after exhausting the various remedial measures through the meatus, and attending to nose and throat, the discharge from the ear still continues, the modern operation for acute mastoiditis should be performed. Chronic suppuration with its possible risks to life will thus be avoided and the future of the hearing safeguarded.

VARIETIES OF ACUTE PURULENT OTITIS MEDIA.

Middle Ear Suppuration in Children.—Otitis media is common in badly-nourished children (Guthrie). Some hold that a mild otitis media is almost universal in infants, the embryonic tissue which may persist in the middle ear cavity after birth being very readily infected. As a rule this tissue disappears within the first few weeks of life. During the first two years, aural suppuration is more frequent than at any subsequent age, and even at five years it is found in 2 per cent of all children. In the vast majority of cases infection is the result of a common cold. The immunity following coryza is short-lived. One cold is followed by another and, with each, the child may have an attack of otitis media. In some cases the symptoms may be lacking or indefinite, the so-called 'latent' otitis. An otoscopic examination should be made in all cases in which an infant is feverish at night without any other obvious cause. As the drumhead of a young child is thicker than that of an adult, there is less tendency to bulging, and spontaneous rupture is delayed (Alexander). The prognosis in the acute cases is favourable, 78 per cent showing no discharge and no deafness when seen from two to five years after the original attack. Removal of adenoids and inflation of the ears by Politzer's method are almost invariably called for.

Recently there has been much discussion regarding the relationship of otitis media to gastro-enteritis in infancy. One school holds that the ear trouble is the cause of the infection of the digestive tract while the other considers that there is little or no connection, and in support of this latter view point out that gastro-enteritis is more frequent in summer and otitis media in winter. Further, the bacteriology of the two conditions does not correspond and operations on the middle ear or mastoid process have very little effect in clearing up the alimentary trouble. It is probable that the gastro-enteritis and its consequent malnutrition are primary and favour infection of the middle ear and nasal sinuses. On the other hand there is a close connection between acute pulmonary conditions, especially bronchopneumonia, and otitis media. Infection of the middle ear is found in 90 per cent of such cases at autopsy: in many there are no local symptoms of otitis media during life.

Influenza.—The incidence of otitis media in this fever varies very greatly. In some epidemics middle ear affections are of frequent occurrence. Earache comes on suddenly from the first to the third day of illness, and may be preceded by a feeling of fullness in the head. Otoscopy frequently shows dark-red vesicles filled with blood on the drumhead or posterior meatal wall, though mastoid tenderness is not yet present. Paracentesis is followed by considerable bleeding, and, later, by a profuse serosanguineous discharge for several days. Later

still the discharge becomes purulent. The infecting organism is usually the *Streptococcus hæmolyticus.* Bayer points out that acute inflammation apparently limited to the attic may occur in influenza. There is at first congestion of the *membrana flaccida* followed by bulging and the formation of a blood blister which extends to the meatal wall. Lastly a perforation occurs but before this paracentesis should be performed. If a cure is not obtained in this way, attico-antrotomy is indicated (*see* p. 359).

Scarlet Fever.—Gardiner finds that from 6 to 10 per cent of scarlet fever cases suffer from purulent otitis media which occurs most frequently in the first or second week of illness. The causal organism is, of course, a streptococcus. Earache, when present, is a fairly reliable signal of ear mischief. Ear discharge occurs, however, twice as often without pain as with it. In the majority of cases the discharge is purulent, less frequently it is mucoid. The discharge has a foul odour in cases complicated by diphtheria.

Appearances of the Drumhead.—Every variation is seen, from mild catarrh to the red bulging membrane with all landmarks obliterated. In the majority of cases the meatus contains desquamated epithelium, and frequently there is a tiny pulsating spot in a greyish-white mass at the medial end of the meatus. Gardiner has not seen the tympanic membrane destroyed in a few hours, or even in a few weeks, though this condition is described as occurring in some cases, especially in those complicated by diphtheria in which necrosis extends to the mastoid bone and some-times even to the labyrinth and in which early and extensive operation is indicated. The perforation in the milder type is usually in the anterior part of the drumhead. In about 50 per cent of cases otitis media is associated with adenoids and mucopurulent rhinitis.

TREATMENT.—Immediate paracentesis in every case in which the tympanic membrane is bulging is the ideal treatment ; but this is only possible in a fever hospital if the parents' consent to such an operation is obtained at the time of admission. Intravenous or intramuscular injections of concentrated anti-scarlatinal serum may be useful. When the symptoms of mastoiditis appear one should operate at once—the 'early' operation is most certainly indicated in these cases, as also in those severe cases following genuine influenza. It has been found that in cases of scarlatinal otitis media the removal of adenoids, combined with the use of specific serum, results in an average reduction of two weeks in the patient's stay in hospital. No case of scarlet fever with otorrhœa should be allowed to leave hospital with the ear discharging. Otorrhœa associated with adenoids may dry up under conservative treatment, but sooner or later the ear begins quietly and painlessly to discharge again. Such patients are often responsible for 'return cases'.

Measles.—According to Gardiner, the onset of otitis media usually occurs in the first or second week, but it may be late in the sixth week. Only in the early cases is there pain. The perforation is anterior as a rule, and the otitis is not so severe as that met with in scarlatina. The organism present is a streptococcus or pneumococcus. Acute mastoiditis is, as a rule, just as free from pain as the otitis media. The only sign

that can be depended on is sagging of the postero-superior wall of the canal. In some cases extensive destruction of the membrane takes place. If operation is performed early, recovery is uneventful, although usually slow. Nitrous-oxide gas and oxygen should be employed to anæsthetize the patient.

Layton holds that in mastoiditis with retro-auricular swelling complicating measles and scarlatina it is advisable to make a free incision (Wilde) at least one inch in length down to and through the periosteum. In the cases in which this incision effects a cure Layton considers that bone disease is absent but that the inflammatory process has passed from the tympanum along the external acoustic meatus to the point where the bony and cartilaginous meatus meet and has then turned backwards over the bone. The Schwartze operation is, however, called for : (1) If the fever does not subside within forty-eight hours after Wilde's incision ; (2) If the wound does not heal within fourteen days ; and (3) If the ear is not dry in two months. Graham Brown, on the other hand, holds that Wilde's incision should be limited to those cases in which the patient cannot stand a general anæsthetic, and in this opinion we agree.

Typhoid Fever.—Otitis media occurs in 7 per cent of cases, usually during the stage of recession. Pain is rarely a marked symptom. The organisms present are those usually associated with acute middle ear suppuration.

Otitis Media due to the Pneumococcus Mucosus or to Friedländer's Bacillus presents important characteristics. There is an acute onset, but in more than half the cases the tympanic membrane does not rupture or the trifling discharge ceases very early. This is followed by a long interval, during which the drumhead presents an almost normal appearance and the patient has only slight deafness and tinnitus, and then an intracranial complication, especially purulent meningitis, suddenly appears. About three months, on the average, may elapse between the first onset of the disease and the appearance of the complication.

MASTOIDITIS IN ACUTE OTITIS MEDIA.

It has already been pointed out that, although the inflammatory process involves the mucosa lining the tympanic (mastoid) antrum in the majority of cases of acute suppuration in the middle ear, the bony walls are affected in only a minority of instances. Krainz points out that, as there are no sensory nerves in the endosteum or bone in the interior of the mastoid process, there may be no clinical signs of mastoiditis till the inflammation reaches its lateral surface or the dura mater of the sinus or brain.

Cheatle states that in infancy, with the exception of the tympanic antrum and a layer of small cells in its lateral wall, the mastoid process contains no cells, the bone being diploëtic. This acellular or infantile type of mastoid process persists throughout life in about 20 per cent of people. In the second type (cellular or pneumatic) the diploë is replaced by air-spaces which have extended from the middle ear tract. Between

the typical acellular infantile mastoid process and the cellular or pneumatic there are several intermediate varieties of bone.

According to the old teaching, the dense bone which is found to surround the antrum in cases of chronic middle ear suppuration was thought to be due to sclerosis from long-standing suppuration. Cheatle's researches have shown that this dense bone is not the effect of chronic suppuration, but the cause of it.

J. P. Stewart points out that in the early stages of mastoiditis the blood-vessels in the Haversian canals become engorged and the muco-endosteal lining of the cells is swollen and infiltrated with leucocytes. Serum and pus cells pass into the lumen. Osteoclasts next appear in the Haversian canals and later in the bony walls of the air-cells. Resorption of bone is also carried on by chemical dissolution (halisteresis) and by vessels which perforate the bone. If the case recovers without operation, the next phase—repair—is seen during the third week and is

PLATE XVII

(A) Normal mastoid air-cells. 1, Dense bone under periosteum of cortex; 2, Haversian space; 3, Delicate layer of mucoperiosteum. (B) Acute mastoiditis. 1, Expanded Haversian canal with dilated vessel and small cell infiltration around; 2, Old bone; 3, Osteoclasts; 4, Dense small cell infiltration of mucoperiosteum which is enormously thickened as compared with A; 5, Blood-vessel. (C) Necrotic form of mastoiditis (rare). 1, Pus in space of former air-cell; 2, Bone decalcified by toxic process; 3, Thickened and infiltrated mucosa of air-cell; below this there are necrotic areas of bone which is still calcified. (D) Reparative process in air-cell. 1, Still unorganized exudate; 2, 6, Narrow bridge of connective tissue which has grown into and is organizing the exudate in the air-cell; 3, Haversian canal; 4, Osteoblasts forming thin layer of new bone; 5, Old bone. (E) Shows final results of reparative process shown in D. The air-cell is now almost completely obliterated. 1, Reticular bone set on cell wall; 2, Endosteum; 3, Small cavities lined by epithelium containing air and a little exudate; 4, Old bone; 5, Organized exudate. The figure shows the so-called 'pearl necklace' arrangement. (F) Low-power view of tip of mastoid showing parts of two air-cells obliterated by new formed bone and fibrous tissue.

manifested clinically by softening of the bone. Thin processes of connective tissue grow out along with young blood-vessels from the muco-periosteum through gaps in the epithelium and pass into the exudate in the air-cell which thus becomes organized. Epithelium proliferates along these tissue bridges which eventually form a series of minute air spaces and produce an appearance which has been compared to a pearl necklace. In other and more severe cases the whole lumen of the air-cell is filled with granulation tissue in which new bone is formed. There is thus a possibility that an originally pneumatic process may become dense; such an occurrence is, however, very rare. In practically all cases of dense mastoid process the air-cells failed to develop (p. 263).

A. Middle ear infection in the acellular type of bone may have the following results :—

1. If drainage is free and if the virulence is slight, cure may occur.

2. If the infection is virulent, the bony walls are affected and the suppuration becomes chronic, with formation of granulations, cholesteatoma, etc. The dense lateral bony wall of the antrum prevents the inflammatory process from spreading to the surface and becoming manifest.

PLATE XVII

;PATHOLOGY OF MASTOIDITIS (Dr. J. P. Stewart)
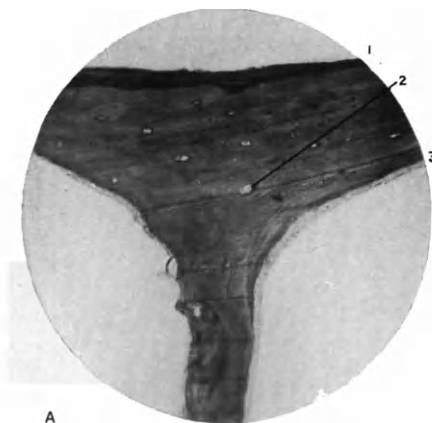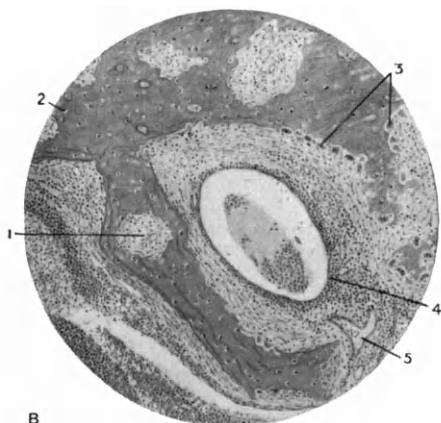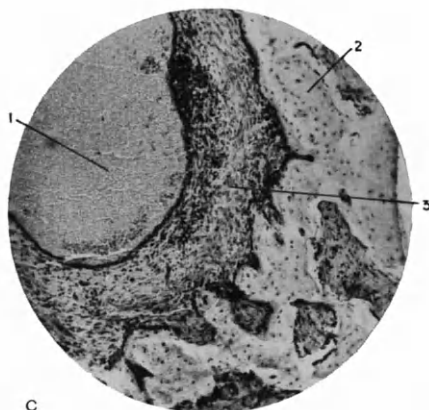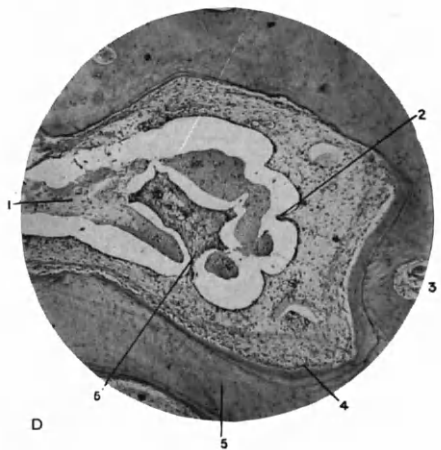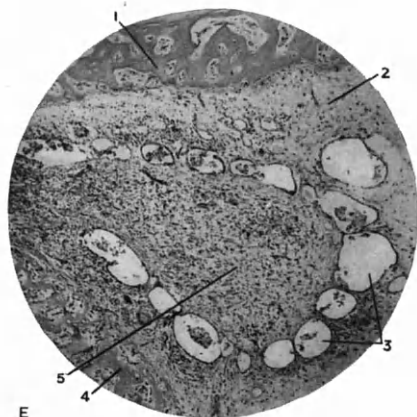
3. A labyrinthine complication due to infection passing through the fenestra vestibuli or fenestra cochleæ may develop at the time of the original infection or later.

4. An intracranial complication may arise (*see* (6) *below*).

B. In severe acute infections of a cellular temporal bone, the sepsis readily travels from the antrum to the cells, where it sets up an acute mastoiditis with external signs. The distance to which the disease may extend is limited only by the extent of the air-cells. The inflammatory process may reach the lateral surface and produce periostitis, the infection in the latter case passing along the perivascular sheaths, or in children by way of the squamomastoid suture. Resolution may occur before pus has formed, if the *iter ad antrum* is not blocked and if there is free drainage through the tympanic membrane. The condition may, however, go on to suppuration, with the formation of a mastoid or subperiosteal abscess. If untreated, the abscess in the mastoid process may burst :—

1. Through the periosteum and skin covering the mastoid process.

2. Into the meatus : this condition may be mistaken for furunculosis of the meatus.

3. Through the thin, medial aspect of the tip of the mastoid process into the digastric fossa (Bezold's mastoiditis). (Treatment in these cases consists in operating on the process and then opening up the sinus from the interior of the mastoid process to the neck. The abscess in the neck is freely opened and drained.)

4. Through the canal for the mastoid emissary vein or through the temporo-occipital suture, with the result that an abscess forms posterior to the mastoid process.

5. Through the posterior root of the zygoma, with the result that a subperiosteal abscess forms beneath the temporal fascia (zygomatic mastoiditis) (*Fig.* 192). According to Mollison, this form of mastoiditis occurs in about two or three per cent of cases. Clinically the condition presents very definite features : pain in front of the ear, and a swelling in the temporal fossa in front of the pinna and above the temporo-mandibular joint. Later, it involves the side of the head up to the insertion of the temporal muscle. Slight œdema of the eyelids may be perceptible before swelling of the face is noticed. There is pain and difficulty in opening the mouth and in mastication. Zygomatic mastoiditis is likely to occur in cases in which the zygomatic cells are unusually developed.

6. The infection may spread—

a. Through the roof of the middle ear cleft and give rise to extradural abscess in the middle cranial fossa, and even to abscess of the temporal lobe. Purulent meningitis is rare when infection spreads along this route.

b. Backward spread of infection may result in : (i) extradural abscess between the dura mater of the descending portion of the transverse sinus (sigmoid) and its bony groove, (ii) sinus thrombosis, (iii) basal lepto-meningitis, (iv) cerebellar abscess.

c. Infection may spread from the tympanum to the labyrinth through the fenestra vestibuli or fenestra cochleæ (*see Fig.* 202, p. 363).

22

d. Infection may pass from the tympanum to the jugular bulb which lies below ; in this case, the infection passes along the smaller veins which drain into the jugular bulb.

e. Lastly, the infection may pass anteriorly from the tympanum outside but along the line of the Eustachian tube and produce a retro-pharyngeal abscess.

SYMPTOMS.—The presence of pus in the antrum is suggested by some degree of tenderness on pressure over the base of the mastoid process, but if the inflammation actually involves these parts, the symptoms become more severe, and usually overshadow those depending on the intratympanic suppuration ; the pain in these cases is generally severe, and the temperature may rise one or two degrees. Vérel stated that mastoiditis alone very rarely causes in adults a rise of temperature to more than 100° F. It is remarkable how many of these patients, even
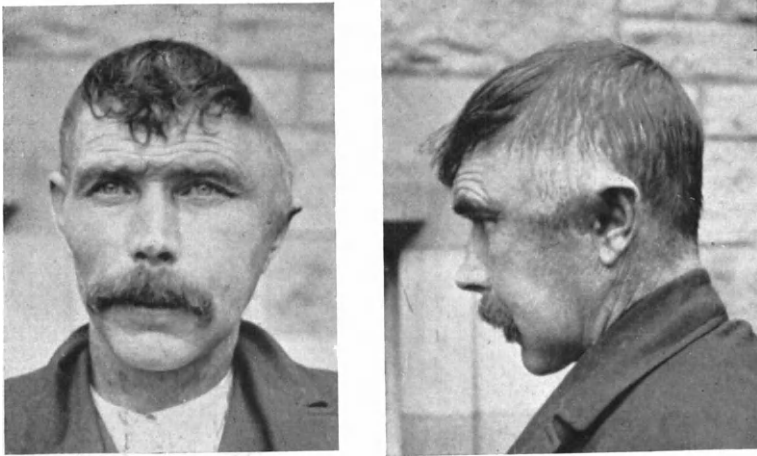
Fig. 192.—Zygomatic mastoiditis. Note the swelling above and in front of the auricle.

with a large subperiosteal abscess, have no fever. In cases with more than this degree of fever, an intracranial complication should be suspected. The pulse-rate is quickened and the mastoid tenderness may be extreme.

In the case of periostitis, œdema of the soft parts develops, and the auricle is displaced downwards and outwards ; this is described as erection of the auricle. The change in position may best be detected if the head is viewed from behind. If a subperiosteal abscess forms, a fluctuating swelling appears behind the ear (*Plate XX*, A, p. 342).

When mastoiditis is present the discharge from the ear is usually abundant, but in some cases a mastoid inflammation occurs after the discharge from the middle ear has ceased and the perforation has healed. This, as has already been mentioned, is most likely to take place in cases due to an infection by the *Pneumococcus mucosus*.

PLATE XVIII

BONE INVOLVEMENT IN OTITIS MEDIA

A   B

Radiographs in a case of unilateral acute purulent otitis media and mastoiditis. (A) Right ear: Normal pneumatic mastoid process. (B) Left ear: Acute otitis media with blurred pneumatic mastoid process.

Radiographs from a case of unilateral chronic middle ear suppuration.
(C) Normal left ear ; (D) Diseased right ear. The antrum was filled with cholesteatoma.

DIAGNOSIS.—The diagnosis of periostitis and mastoid inflammation is generally easy, but in some cases difficulty may arise in distinguishing between furunculosis of the posterior meatal wall with surrounding cellulitis, and mastoiditis (*see* p. 316). In undoubted cases of mastoiditis there may be difficulty in deciding whether the condition has passed the catarrhal stage and gone on to actual pus-formation, as there is usually little or no pyrexia or increase of the pulse-rate, while the pain may be slight and the objective appearances indefinite. In such cases, considerable information may be obtained from a radiograph taken to show the mastoid region of the skull. For this purpose the tube is placed so that the rays pass obliquely through the side of the head from the parietal region down towards the opposite mastoid area. Each side of the head is photographed separately, for the purpose of comparison. A postero-anterior radiograph should also be taken to show the tip cells on both sides. Anatomical asymmetry of the mastoid process is found in only 12 per cent of cases (Turner and Porter). The radiograph shows the type of mastoid process and, if cellular, the distribution of the cells ; it also demonstrates the position of the transverse sinus, antrum, etc. The conditions found at operation are generally in agreement with what is shown in the radiograph. In acute otitis media, changes may be noted even during the first few days, a slight blurring of the outline of the cells on the affected side indicating tumefaction of the lining membrane. If resolution takes place, this blurring persists for a considerable period. Pus, if present, will be indicated by an area of cloudiness, while the outlines of the cells in a cellular process will also be blurred. As in the case of radiography of the paranasal air-sinuses, some experience is required in the interpretation of the pictures which are obtained. (*Plate XVIII*, A, B.)

Dixon states that the blood-count in simple acute mastoiditis shows an average of 11,000 to 12,000 leucocytes, while the polynuclear count yields about 70 to 80 per cent. Though it is not possible by means of a leucocyte count to diagnose between an uncomplicated case of otitis media and one complicated by mastoiditis, a leucocytosis of over 20,000 indicates the presence of some complication (intracranial or chest).

TREATMENT.—When symptoms of inflammation of the mastoid process supervene, the patient should be sent to bed and, if the condition is not urgent, palliative measures should be adopted in the first place. The bowels may also be evacuated by a dose of calomel at night (3 to 5 gr.), followed by a saline cathartic in the morning. The pain may be relieved by the application of cold by means of an ice-bag or by running iced water through Leiter's tubes. Free drainage through the drum-membrane is essential, and paracentesis must be performed if the perforation is not already sufficiently large to permit of this. It must be confessed, however, that, once signs of serious mastoiditis have developed, as indicated by pain and 'late' tenderness, paracentesis seldom or never aborts the process. Operation on the mastoid process is almost invariably necessary.

There is considerable controversy as to the most suitable time to operate in cases of mastoiditis. Alexander believes that it is advisable to wait as long as possible—six weeks by preference, as at this period

the interior of the process has broken down into a confluent abscess, and at the end of the operation the wound can be closed. Neumann, on the other hand, points out that if operation is performed in the first or second week, intracranial complications are seldom met with (2 per cent), whereas in cases operated on after the seventh week such complications, e.g., perisinus abscess, are found in 75 per cent. The teaching in Edinburgh is intermediate between these views (*see* 6 *below*).

The indications for the simple mastoid operation, which is also known as Schwartze's or the 'classical' operation, in cases of acute purulent otitis media, are as follows :—

1. Pain and mastoid tenderness continuing for two or three days in spite of paracentesis.

2. Fever (over 100° F.) and rapid pulse in an adult.

3. Copious pulsating purulent discharge filling the meatus within a few minutes after mopping out, and therefore too plentiful to be secreted by the tympanum and antrum alone.

4. Sagging of the meatal wall ; œdema or subperiosteal abscess over the mastoid process or zygoma, or gravitation abscess below the tip of the process.

5. Symptoms of labyrinthine or intracranial complication call for opera-tive treatment. (These subjects are dealt with in Chapter XXXVIII, p. 361.)

6. Persistence of acute suppurative otitis media for more than four weeks in spite of efficient treatment.

Technique of the Classical Mastoid Operation (Schwartze) (Plate XX). —The skin around the mastoid process is shaved and prepared in the usual way with iodine, and the head covered with sterile cloths which leave the area of operation exposed. The auricle is held forward by an assistant, and an incision is made through the skin a quarter of an inch behind the retroauricular groove. The cut should extend down to the bone and beyond the tip of the process (*Plate XX,* B). The peri-osteum is separated forwards and backwards so as to expose the mastoid cortex, including the posterior root of the zygoma, the suprameatal spine and the tip of the mastoid process. A self-retaining retractor is then inserted (*Plate XX,* C). With the aid of the gouge and hammer the mastoid cortex is now removed, the gouge cuts being made from behind forwards. The large shallow bony cavity thus formed is then deepened in a direction parallel to the posterior bony meatal wall until the tympanic antrum is reached (*Plate XX,* D). As a rule this cavity lies about half an inch from the surface at a point just behind the suprameatal spine. (It is a good plan at this stage to take a swab of the pus from the antrum and to get a vaccine prepared from it.) Diseased cells should be followed up, though this may necessitate the opening up of the zygomatic cells above the external acoustic meatus, and the exposure of the dura mater of the middle fossa. Eisinger of Vienna teaches that the three constant planes in connection with the mastoid bone are the posterior meatal wall, the middle fossa and the posterior fossa and that the gouge should be directed in these planes ; thus the first blow is made parallel to the posterior meatal wall, the

PLATE XIX

BONE INVOLVEMENT IN OTITIS MEDIA

A
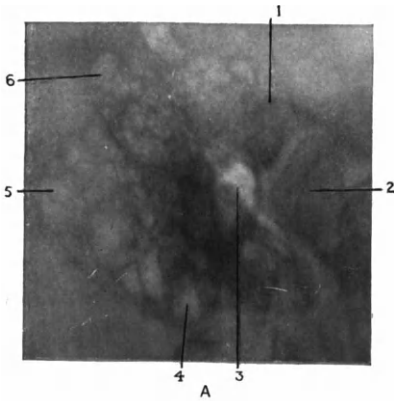
Radiograph of right mastoid process showing extensive development of air-cells. (1) Zygomatic cells; (2) Condyle of mandible; (3) External acoustic meatus; (4) Cells at tip of process; (5) Marginal cells (the clear area in front of this line indicates the position of the sigmoid sinus); (6) Posterior-superior or petrosal-angle cells.

B
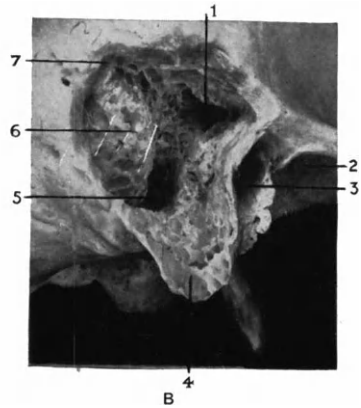
A photograph kindly presented by Professor Neumann to show the operation for acute mastoiditis carried out at his clinic. (1) Antrum; (2) Glenoid fossa; (3) External acoustic meatus; (4) Cells at tip of process; (5) Sub-labyrinthine cells; (6) Bulging of sinus plate into the operation cavity; (7) Posterior superior or petrosal-angle cells.
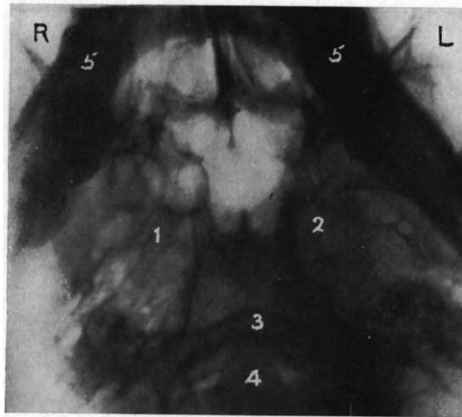
Vertical radiograph of head of patient with acute inflammation of cells at apex of left petrous pyramid. The radiograph also shows a large, normal left sphenoidal sinus: the left posterior ethmoidal cells are cloudy. (1) Normal cells of pyramid on right side; (2) Cloudy cells on left side; (3) Anterior arch of atlas; (4) Odontoid process of axis; (5) Mandible.

second parallel to the middle fossa and the third parallel to the posterior fossa. By working on these planes the various cell systems are automatically opened up and drained. The various groups of cells described by Cheatle and also by Neumann (*see* chapter on ANATOMY, pp. 262, 264) should be systematically searched for and opened up (*Plate XIX*, A, B). Formerly it was not very uncommon for the patient to have a rise of temperature and headache two or three weeks after an imperfect Schwartze operation and, on opening up the wound, it was found that all the cells had not been cleared out. In all cases in which the patient has a temperature of over 100° F. before operation the sinus should be exposed. Signs such as œdema or tenderness over the posterior border of the mastoid process, and symptoms such as retraction of the head, vomiting, rigors, or feelings of chilliness, call for the exposure of the sigmoid sinus. In exposing the dura mater of the sinus or middle fossa the gouge should be directed at a very oblique angle to the surface, so that there may be no danger of penetrating the dura mater.

In the majority of cases it is also advisable to remove the tip of the mastoid process, in order to provide free drainage from the lower end of the wound. This procedure should certainly be followed in all cases in which the cells extend down to the tip. The fibres of insertion of the sternomastoid muscle are separated with the periosteum-detacher, or with the knife or scissors, and the edges of the wound held apart with retractors. A broad gouge is now applied to the posterior aspect of the mastoid tip. One blow with the hammer and gouge severs this portion. In the same way the gouge is applied to the antero-lateral surface of the tip (*Plate XX*, E and F). In this way the tip of the mastoid process is loosened, but is still held by the sternomastoid fibres attached to its medial surface. The mastoid tip is therefore grasped by means of necrosis forceps and pulled first forwards and then backwards, while the remaining fibres of the sternomastoid insertion are detached with a pair of scissors curved on the flat. If a gravitation abscess is present beneath the sternomastoid muscle, this must be followed up and drained by a counter-opening in the neck on general surgical principles.

The cavity is now swabbed with peroxide of hydrogen, syringed out with warm saline solution, and lightly packed with iodoform worsted or gauze, which should protrude from the lower end of the wound. As an alternative a drain of rubber dam may be employed. Stitches are usually inserted in the upper three-fourths of the incision.

At the end of the operation the external meatus should be lightly packed with a strip of iodoform gauze. The dressing and bandage are now applied in the usual way.

If all goes well and the temperature remains normal, the case need not be dressed for at least five days, when the drain and stitches are removed. At the first dressing the surgeon hopes to find the gauze in the external meatus dry, showing that the suppuration in the tympanic cavity is passing off. It is useless to allow the posterior wound to close before the tympanic cavity has ceased to discharge. If the meatal discharge continues, an autogenous vaccine (*see above*) may sometimes be of service.

In operating on infants it is necessary to remember that the mastoid process is poorly developed, and that the antrum is higher up and much more superficial than in adults, also the facial nerve is much more superficial.

During the last ten years certain surgeons have employed the 'blood-clot' method of healing after the Schwartze operation. This method is carried out as follows : When all diseased tissues have been thoroughly removed, the cavity is syringed, dried out with swabs moistened with spirit, treated with B.I.P.P. of creamy consistence, and allowed to fill with blood. The wound is then united throughout its whole length and dressings are applied (Tilley). Dowey reports on 45 cases with the following results : healing by first intention, 31 per cent ; complete breaking down of wound, 47 per cent ; partial breaking down, 22 per cent. Tilley reports 95 per cent of cases treated by the blood-clot method as completely successful. Early cases dealt with in this way do not, as a rule, heal by first intention, whereas those of three to six weeks' duration in which free pus is present in the mastoid are more successful. *It is, however, safer to drain the operation cavity at the lower end.* Loose sutures may be passed at the lower end of the wound and united at the first or second dressing if all is satisfactory and the meatal discharge has ceased. In this way it is possible to obtain the cosmetic advantage of the 'blood-clot' method without the danger associated with the complete closure of the wound. The patient may be sent home within two weeks in favourable cases. Yet another method is to sew up the posterior wound margins but to insert a piece of capillary tubing into the operation cavity and bring one end of it out at the upper and lowermost portion of the incision.

The Schwartze operation results in the cure of the discharge in 90 per cent of cases, and in the return of normal hearing in 70 per cent.

INFLAMMATION OF THE CELLS AT THE APEX OF THE PETROUS PYRAMID OF THE TEMPORAL BONE

(APICITIS OR PETROSITIS)

This inflammation may be either present in its acute or chronic form. In the former it is manifested by profuse aural discharge accompanied by retro-orbital pain. Paralysis of the 6th nerve may be present (*see* GRADENIGO'S SYNDROME, p. 371).

The patients are young and the otitis media is sometimes, but not always, accompanied by mastoiditis. There is severe pain usually with a temporo-parietal distribution caused by irritation of the Gasserian ganglion at the tip of petrous pyramid (*Plate XIX*, C). Hyperæsthesia or anæsthesia of the skin associated with herpes may be present. The motor part of the 5th nerve is occasionally involved with spasm or paralysis of the muscles of mastication. Then diplopia may suddenly develop due to the involvement of the abducens nerve. Optic neuritis is absent. On lumbar puncture the cerebrospinal fluid is usually under increased pressure, but otherwise normal. Within two months, sometimes

PLATE XX

SCHWARTZE'S OPERATION FOR ACUTE MASTOIDITIS
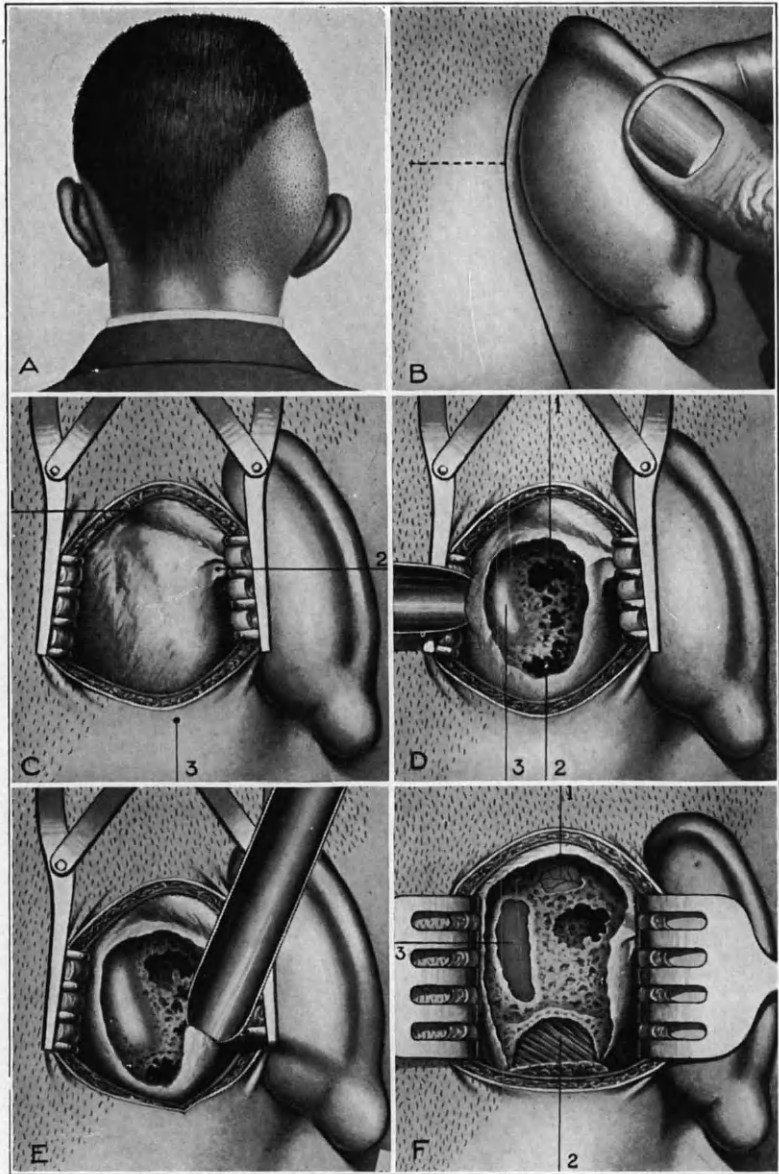
(A) Subperiosteal abscess over right mastoid. (B) Line of incision. The dotted line indicates a second incision which may have to be made in cases in which the sinus has to be exposed. (C) Area of operation exposed: (1) Posterior root of zygoma; (2) Suprameatal spine; (3) Tip of mastoid process. The area of operation lies within the triangle made by joining these three points. (D) Mastoid antrum opened: (1) Mastoid antrum; (2) Air-cells at the tip; (3) Sinus plate. The gouge is shown in the position for removal of bone to expose the sinus. (E) Removal of tip of mastoid. (F) The operation completed: (1) Dura of middle fossa exposed: (2) Posterior belly of digastric muscle exposed by removal of mastoid tip; (3) Exposure of sigmoid sinus.

following surgical interference and sometimes in its absence, the pain becomes trifling and the diplopia vanishes. Occasionally a diffuse meningitis or cavernous sinus thrombosis supervenes and the case ends in death. Sears, in reviewing 250 cases where the Gradenigo's syndrome was present, reports a mortality rate of 17 per cent.

In its chronic form it may keep up an aural discharge. Kopetzky makes his diagnosis from the following : (1) Persistent otorrhœa following efficient simple mastoidectomy ; (2) Failure to find any further pathology within the mastoid process on revision of the original operation or the discovery of a fistula leading to the petrous apex ; (3) Positive finding on radiographic examination (vertical projections are most suitable), and if attacks of retro-orbital pain are present, the diagnosis is made from clinical findings alone.

TREATMENT.—In cases associated with acute middle ear suppuration the patient should be carefully watched and palliative treatment undertaken for a week. Lumbar puncture should be performed. Pain will have to be relieved by morphia. Paracentesis and (or) the Schwartze operation may be necessary. If the symptoms abate we may assume that the patient will recover without further operation ; but if after a week no relief has been obtained, the radical mastoid operation should be performed. Probably the most simple procedure is next to remove the entire tegmen and elevate the dura mater of the middle cranial fossa from off the anterior surface of the petrous bone ; the apex is thus brought into view and the apical cells curetted.

An alternative route is that employed by the cranial surgeon for removal of the Gasserian ganglion.

OSTEOMYELITIS OF THE TEMPORAL BONE.

Osteomyelitis of the temporal bone, following middle ear suppuration, is fortunately rare and, like osteomyelitis elsewhere, is a disease of childhood. The symptoms develop rapidly. The general condition of the patient is serious, with high temperature, prostration and restlessness. The retro-auricular swelling appears early and extends rapidly beyond the limits of the mastoid process. The swelling has an œdematous border. At operation, pus is abundant and usually very fœtid. The mucous membrane is necrotic and the bone itself softened and also necrosed. Foci of osteomyelitis are found at a distance, the infection passing by way of the diploic veins. The transverse sinus often becomes thrombosed. The infection, spreading either directly or leaving areas of apparently healthy tissue, may reach the vault or the base of the skull. In the majority of cases, septicæmia, pyæmia, or more rarely leptomeningitis, carries off the patient. Operation can hardly be too early or too radical.

MASTOIDITIS IN DIABETICS.

If a patient suffering from diabetes gets an attack of acute suppurative otitis media, mastoiditis is likely to be specially dangerous. Treatment by insulin and appropriate dieting are called for. If possible the

urine should be free from sugar and acetone before operation. Local anæsthesia is frequently employed in these cases. The operation should be performed as rapidly as possible, and diseased bone should be removed freely. The technique of local anæsthesia is as follows : Heroin ($\frac{1}{12}$ gr.) and atropine ($\frac{1}{150}$ gr.) are given hypodermically an hour before operation. For local anæsthesia a sterilized solution of 0·5 novocain is employed. Three or four drops of adrenalin (1–1000) are added just before injection. The skin is anæsthetized along the line of incision from above the auricle to one inch below the tip of the mastoid process. At this point a deep injection is made to block the great auricular nerve. The small occipital is blocked by an injection about an inch and a half posterior to the meatus and on a level with the floor of the canal. The needle is next pushed deeply into the groove behind the auricle, under the periosteum along the posterior wall of the canal, where further injections are made. Finally, the needle is thrust under the mastoid periosteum over the line of incision in four or five places. The surgeon must wait from ten to fifteen minutes after the last injection before he begins to operate.

Intravenous injection of evipan is of great value as an anæsthetic in these cases, also, if a general anæsthetic is desired, gas and oxygen may be administered.

PHARYNGEAL ABSCESS.

Pharyngeal abscess secondary to suppurative otitis media may develop in two ways : (1) directly, from the tympanic and tubal air-cells—the infection passing along the inferior surface of the petrous bone in close relation to the auditory tube, or (2) indirectly, from air-cells situated deeply in the mastoid temporal, or from an extradural abscess in the posterior cranial fossa—the pus first forming in the suboccipital region deep to the digastric muscle. In most of the latter cases the pus tends to pass backwards; but in a few, owing to weakness of the aponeurotic barriers due to the passage of a vein, the pus infiltrates towards the pharynx (Jacques). In pharyngeal abscess of otitic origin the patient (very commonly a child in whom the median group of retropharyngeal glands is present and into which drains the lymph from the middle ear and Eustachian tube) complains of pain or difficulty in mastication and swallowing, or of toothache or pain in the parotid region. The speech is 'thick'. On examination there is redness and swelling of the lateral wall of the pharynx or of the peritonsillar region. For the treatment of subpetrous abscess in its early stage, McKenzie recommends removal with a gouge of part of the anterior wall of the external bony meatus, deep to the mandibular joint. After pus has been evacuated, the cavity is lightly packed. In the later stages, when there is bulging of the pharyngeal wall, the abscess should be opened through the mouth by Hilton's method (*see* PERITONSILLAR ABSCESS, p. 132). Only if widespread cellulitis is present in the neck is external operation indicated.

Intracranial Complications will be considered later (Chapter XXXVIII).

CHAPTER XXXVII.

CHRONIC PURULENT OTITIS MEDIA AND COMPLICATIONS.

CHRONIC PURULENT OTITIS MEDIA.

ETIOLOGY.—Chronic suppuration of the middle ear results from an attack of acute inflammation, and accordingly the causes are the same in both cases. If all patients suffering from acute purulent otitis media were efficiently treated, there would be a great diminution in the number of chronic cases. Chronic suppuration is, however, especially liable to follow in cases due to scarlet fever, measles and diphtheria. The resisting power of the patient must not be overlooked. Chronic middle ear suppuration is far more common among the poorer sections of the population than among the more wealthy, but this may be explained by the fact that among the latter acute inflammation of the ear is rarely allowed to become chronic. Cheatle examined the ears of 1000 poor school-children, and found that 88 were suffering from chronic middle ear suppuration. Further, the examination of 35,000 candidates for the Royal Air Force showed that about 5 per cent suffered from chronic purulent otitis media. The presence of nasopharyngeal infection is an additional and important factor in keeping up an aural discharge.

SYMPTOMS.—Discharge from the ear, impairment of hearing, and perforation of the tympanic membrane are the chief symptoms and signs of chronic middle ear suppuration, but they vary greatly in degree. The discharge may be very profuse and mucopurulent, especially in cases in which the Eustachian tube and anterior part of the tympanum are affected. On the other hand, the discharge may be so slight as entirely to escape the patient's notice ; indeed, a small crust of dry pus on the posterior wall or roof of the meatus may be at first the only evidence of the presence of discharge. After removal of the crust the perforation is usually evident. The discharge may be extremely foetid, or devoid of smell. (Adam states that in neglected cases there is sometimes erosion of the skin lining the acoustic meatus, which is covered by a thin greyish membrane. The discharge is very foul and hæmorrhagic from bleeding granulations. On microscopic examination of the discharge, Vincent's organisms are found.) The impairment of hearing may also be so slight as to be negligible, or the deafness may be extreme ; in the latter case there is generally involvement of the stapediovestibular joint (otosclerosis) or of the inner ear.

Tinnitus is an occasional symptom, but is rarely well marked.

Pain is not common and is nearly always a grave symptom. It may be due to defective drainage, or it may be evidence of the beginning of a serious or even fatal complication.

Vertigo is also present occasionally. If marked, it is usually due to erosion by disease of the bony wall of the lateral semicircular canal on the medial wall of the aditus (labyrinth fistula), but may possibly be caused by pressure on the stapes, or extension of the suppuration to the labyrinth. Many patients complain of vertigo when the ear is syringed. The surgeon should see that the lotion is of the proper temperature— about 100° Fahrenheit.

APPEARANCES.—The drum-membrane is frequently hidden, owing to the presence of pus or of inspissated secretion ; and in such cases the ear should be syringed and dried out with cotton mops in order to obtain a satisfactory view of the parts. On subsequent inspection of the ear, a perforation may frequently be seen, which varies greatly in size, in some cases being no larger than a pin-head, while others involve practically the whole area of the membrane. As a rule, the perforation is single (*Plate XVI*, 9, 10, 13, and 14 p. 304), but occasionally two or even three perforations may be present. The remaining membrane may be red and swollen, or merely thickened. The position of the perforation should be noted : whether it occupies the central portion of the membrane or extends to the annulus tympanicus (marginal perforation). Perforation of the membrana flaccida should always be looked for (*Plate XVI*, 14). In order to observe this area the patient's head should be tilted towards the shoulder of the side opposite to the ear under examination.

In a considerable number of cases the drum-membrane is hidden by the presence of an aural polypus in the external meatus. As a rule the polypus grows from the annulus tympanicus or the inner tympanic wall (promontory) and its stalk passes through the perforation. In other cases the drumhead may be partially hidden by granulations growing from the posterior margin of the annulus tympanicus or protruding through an attic perforation (*Plate XVI*, 11 and 12).

PROGNOSIS.—The presence of chronic middle ear suppuration is always a source of risk to the patient. Such cases are seldom accepted for life assurance, or, if they are, the policy is heavily 'loaded'. The danger is greater in childhood and early adult life than in middle and old age, for intracranial complications are more liable to occur in the young. The risks are greater in the poorer than in the more wealthy classes, owing to the prevalence among the former of the idea that a discharge from the ear is a trivial matter, and the consequent lack of attention they pay to it. Hence we find that a much larger percentage of patients require mastoid operations in hospital than in private practice. In Edinburgh the patients attending the Royal Infirmary are drawn from 80 to 85 per cent of the population of the district, leaving 15 to 20 per cent as belonging to the category of private patients ; among 306 radical mastoid operations performed in Edinburgh during a period of six years, it was found that only 9 cases (3 per cent) were private patients, the remaining 297 being operated on in the Infirmary. Various other factors influence the prognosis ; thus, in infection arising as a sequel to the exanthemata, there may be extensive destruction of the drum-membrane and marked impairment of the hearing, while mastoid and other complications are also more liable to occur. The position of

the perforation is also of considerable importance. Perforations of the anterior part of the drumhead (*Plate XVI*, 9) are seldom of serious significance as regards danger to life. They indicate a chronic tubotympanic infection, and call for treatment of nose, pharynx and Eustachian tube rather than for a mastoid operation. 'Central' perforations in the posterior inferior quadrant are associated with suppuration in the lower part of the tympanic cavity. A combination of these two varieties results in a ' central ' kidney-shaped perforation in the lower half of the drumhead (*Plate XVI*, 10). These three kinds of perforation may be regarded as favourable from the point of view of prognosis, because intracranial complications are seldom met with in such cases. Perforations in Shrapnell's membrane (*Plate XVI*, 14), and marginal perforations in the posterior superior quadrant (*Plate XVI*, 13), are to be looked upon as more serious than those which are centrally placed : the first, because they indicate an attic suppuration, and the second because they are associated with caries of the incus, suppuration in the tympanic antrum, and probably also with erosion by cholesteatoma of the walls of the aditus and antrum. The character of the discharge is of importance in prognosis. A definitely purulent, fœtid one is of more serious significance than a mucoid secretion, even if profuse. The latter, as has already been stated, is present in cases of purulent catarrh in the tube and lower portion of the tympanum.

Before any operation is performed on a case of chronic middle ear suppuration, the function of the cochlear and vestibular apparatus should always be examined. The hearing power of the affected ear should be tested, first with the healthy ear occluded by the finger and, secondly, with the noise-box applied. The rotation, caloric and fistula tests should also be carried out (*see* pp. 292-295). By submitting a patient with undiagnosed latent suppuration in the labyrinth to the mastoid operation, or even to removal of an aural polypus, he is exposed to the danger of purulent leptomeningitis.

TREATMENT.—One of the chief desiderata in the treatment of chronic middle ear suppuration is cleanliness ; this can best be secured by syringing the ear. The routine treatment is as follows :—

1. Place the patient's head horizontally on a pillow or cushion, with the affected ear uppermost, and instil 10 to 15 drops of a solution of peroxide of hydrogen (10 vol.). The drops should be allowed to remain in the ear for five minutes, or until they cease to bubble.

2. Let the patient sit upright, holding a kidney-dish below the affected ear, and syringe the ear with warm boracic lotion (boric acid, 1 drachm, to a pint of lukewarm boiled water) ; a dilute solution of lysol (half a drachm to the pint of lukewarm boiled water) is often employed. A metal syringe, of three- or four-ounce capacity and provided with three finger-holes, should be used. Small glass or rubber syringes are almost useless.

3. Dry the ear with sterile wool mops.

4. Inflate the ear by Politzer's method.

5. Dry the ear again with sterile wool mops.

6. Instil ten drops of a solution of boric acid in rectified spirit (10 gr. to the ounce).

The treatment is repeated from one to three times a day, according to the amount of discharge. If the treatment is being carried out by one skilled in ear surgery, intratympanic syringing may be employed under the guidance of reflected light.

Guthrie recommends drops of a 1 per cent solution of picric acid in 70 per cent alcohol. Some writers advise the use of Calot's solution (*see* Appendix) as follows. The meatus is cleansed, and 10 drops of the solution are instilled and forced into the deeper parts of the ear by pressure on the tragus. The pressure must be continued until the patient feels that the solution has passed into the nasopharynx. Trétrop recommends a freshly prepared, watery solution of 1–1000 bichloride of mercury mixed with equal parts of glycerin. This solution is instilled several times a day, and thereafter the meatus is lightly packed with a gauze wick. Hubbard advises the use of anæsthetic ether ; the ear is syringed before the treatment commences, but not again. The external meatus is filled with ether, which gives rise to pain of short duration. In fifteen minutes the ether has evaporated.

When the secretion is mucopurulent, syringing the middle ear through the auditory (Eustachian) tube is sometimes efficacious. The catheter is passed and air injected to make sure that the instrument is in position. An ear syringe with a nozzle which fits the proximal end of the catheter is employed to wash out the Eustachian tube. At least some of the fluid passes through the perforation and out of the meatus to be caught in a kidney-dish held below the ear. Thereafter air is again inflated. Finally, a solution of argyrol (2 to 10 per cent) may be injected into the catheter by means of a small Pravaz syringe and blown up the tube with the Politzer bag.

As an alternative to syringing through the auditory tube by means of the Eustachian catheter, the following method may be employed. The external meatus is first cleansed by syringing in the ordinary way. A syringe with a bulbous nozzle is then used, the nozzle being fitted tightly into the outer opening of the meatus. The piston of the syringe is then slowly forced home, and in this way the fluid in the syringe passes through the perforation and the Eustachian tube and drips slowly from the patient's nose, to be caught in a basin held below the chin. The fistula bag is then inserted into the meatus and compressed in order to dry out the passages. Finally, argyrol may be instilled into the meatus and driven through the Eustachian tube in the same manner.

If the discharge is very fœtid, formaldehyde (40 per cent), 20 drops to a pint of boiled water, or one of the following lotions, may be used for syringing : creolin (1 per cent), perchloride of mercury (1–3000), or ℥i of eusol to the pint of warm water.

During recent years many otologists—especially those who have had to deal with soldiers in the field—have condemned the treatment of chronic middle ear suppuration by means of syringing (wet treatment). These writers advocate the 'dry method', i.e., careful mopping out of the aural discharge with cotton-wool, and the instillation of boric acid and spirit drops.

In cases where there is a large perforation associated with scanty

discharge, treatment with powders is often efficacious. The ear is syringed and carefully dried ; sufficient powder is then insufflated to form a thin film on the perforation and membrane. Boric acid, with or without the addition of iodine, aristol, orthoform or xeroform may be used for the purpose. The treatment may be entrusted to an intelligent patient.

Friel states that ionization is a suitable line of treatment in cases in which the sepsis is confined to the tympanum and does not involve the attic or antrum, and when the perforation of the drumhead is large enough to allow the zinc solution to enter the middle ear. The technique is as follows :—

The affected ear should first be cleansed by syringing with boric lotion and dry mopping, and then syringed with the zinc solution (zinc sulphate 75 gr., glycerin 2 fl. oz., water to 35 fl. oz. ; an equal quantity of hot water is added). With the patient lying on the sound side, the affected ear is now filled with zinc solution, air-bubbles being removed by aspira· tion with a pneumatic speculum. In some cases the zinc solution may be introduced by means of the intratympanic syringe. The positive electrode, consisting of a zinc wire surrounded by a vulcanite speculum, is then placed in the meatus. The indifferent electrode attached to the negative terminal is applied to the arm or leg over a towel wet with saline. The current is gradually increased to 3 or 4 ma., allowed to flow for ten minutes, and diminished to zero before the speculum is removed. If the current is diminished too quickly the patient complains of giddiness and is apt to vomit. The treatment is successful in cases in which the sepsis is confined to the mucous membrane of the tympanum. If the suppuration does not yield to two or three applications, it is probably useless to continue (Stephen Young).

It may be stated generally that conservative treatment of chronic middle ear suppuration by means of drops and syringing, *if efficiently carried out*, results in cure in 50 per cent of cases. A further 25 per cent may be cured by special methods, such as syringing through the Eustachian tube, intratympanic syringing, or the use of zinc ionization. Most of the remaining 25 per cent require operation (radical or modified radical mastoid operation). Out of 1893 cases of chronic middle ear suppuration seen at the Royal Infirmary, Edinburgh, during five years, 424 underwent the mastoid operation.

When the suppuration ceases, leaving a dry perforation, water should not be allowed to enter the meatus, as it may cause a recurrence of the suppuration ; sea-bathing should therefore be prohibited, and a pledget of wool worn in the ear when the patient has a bath. As it is very desirable that the perforation should heal, an attempt may be made in such cases to induce cicatrization by painting its edges with trichloracetic acid. Occasionally a change of irritant is useful, e.g., liquor ferri perchlor., or silver nitrate. For dry perforation Gomperz recommends a disc of silver foil, which causes no irritation to the mucosa.

The impairment of hearing varies enormously in different cases ; it may be very slight even in the presence of large defects in the mem· brane ; but when marked, the effect of an artificial drum should be tried.

The simplest and most effective form of drum (also fortunately the cheapest) consists of a pledget of cotton-wool. A small piece of wool is made into the shape of a pear, and moistened in liquid paraffin or boroglyceride ; it is then placed against the perforation with a pair of forceps which grasp the narrow end. If this improves the hearing, the patient should be taught to make and introduce the pledget, and in a short time he will probably be able to do it with more success than the surgeon. The artificial drum should be worn at first only for an hour or two at a time, but later it may be allowed to remain in the ear all day ; it should, however, always be removed at night, a fresh piece being inserted each morning. The practice must be discontinued if a recrudescence of the suppuration occurs.

CHOLESTEATOMA.

Cholesteatoma is associated with chronic middle ear suppuration in one-third of all cases (Nager). It is only found when the perforation is marginal or in the attic region—never in central perforations. It consists of a matrix or germinal layer attached to the bony wall of the antrum or attic, from which masses of squamous epithelium are cast off. These are concentrically arranged, with here and there crystals of cholesterin. To the naked eye it generally appears as a smooth, glistening and pearly body, but in other and more septic cases it looks like a mass of putty and smells abominably. The layers of epithelium accumulate, exercise pressure on the surrounding bone and erode it ; on removal of the cholesteatoma, the underlying bone is found to be smooth and highly polished. The cholesteatoma not infrequently erodes the bony wall of the lateral semicircular canal, producing the so-called ' fistula '. It may invade the labyrinth and also the middle and posterior fossæ of the skull. Extradural abscess, sinus thrombosis, brain abscess, meningitis, and facial paralysis are not uncommon results of cholesteatoma. Occasionally after a mass of cholesteatoma has been removed, it leaves an appearance as if nature had performed the radical mastoid operation.

PATHOLOGY.—There are three theories as to the origin of cholesteatoma : (1) Dan McKenzie holds that most cases of cholesteatoma are primary, i.e., due to inclusion of epidermic cells in the middle ear during fœtal life. As it grows, the cholesteatoma erodes the bone or the drumhead. Suppuration, if it occurs, is a sequela of the cholesteatoma and not the cause. This view, however, has not met with general acceptance. (2) Most otologists believe that it is due to the ingrowth into the tympanic cavity, aditus and antrum of squamous epithelium from the external auditory meatus or outer surface of the drumhead. (3) Others hold that it is produced by a metaplasia of the epithelium of the middle ear cleft as the result of chronic suppuration. Similar changes are found in the mucous membrane of the bronchi in cases of bronchiectasis, in the nose in ozæna and in some cases of chronic suppuration of the frontal air-sinus ; in these cases the changes must be due to metaplasia. Cholesteatoma of the attic is frequently met with and may be accounted for as follows. (a) Retraction of the membrana flaccida may result in a sac filled with desquamated epidermic cells. This sac may rupture

medially and lead to infection of the attic and antrum. (*b*) Acute suppuration localized in the attic may occur in influenza : if recovery does not take place chronic attic suppuration with cholesteatoma formation may arise. The cholesteatoma mass is often very septic, and usually contains the *B. proteus*.

SYMPTOMS.—The condition may be dormant for years, but its presence always constitutes a risk to the patient, as suppuration in cholesteatoma is easily induced. Giddiness and pain are frequently present, but the symptoms vary greatly.

DIAGNOSIS.—This is not always easy, but the projection of masses of epithelium through a perforation is characteristic (*Plate XVI*, 13 and 14 p. 304) and the frequent washing out of epithelial scales by the intratympanic syringe is suggestive. In cases of cholesteatoma the pus is thick and fœtid and contains small white particles. Milligan has drawn attention to the presence of acid-fast squames in the discharge as a point of value in diagnosis. The washings may further be examined for cholesterin crystals.

TREATMENT.—The ordinary treatment of chronic otitis media is not effective in cases of cholesteatoma. Intratympanic syringing in skilled hands may prevent accumulations, but seldom results in cure. Rejtö advises the injection of 5 c.c. of carbon tetrachloride through an attic syringe. If it fails, the radical or the modified radical mastoid operation should be performed.

GRANULATIONS AND POLYPI.

These are frequently met with in chronic suppuration, and much more rarely in acute inflammation. Polypi arise from granulation tissue which is a lowly-organized connective tissue. Granulations may spring from the tympanum or the attic, or may proceed from a sinus in the bone lateral to the membrane. The distinction between granulations and polypi is somewhat arbitrary. Granulations are sessile red growths which bleed readily when touched (*Plate XVI*, 11 and 12).. Polypi vary greatly in size and appearance ; they may be little larger than a pin's head, or they may entirely fill the meatus, and even project beyond it ; one or more may be met with and, unless very small, they are usually pear-shaped, being constricted where they pass through the tympanic membrane. They may be bright red, or if large and projecting from the outer opening of the meatus they are skin-coloured. Ruttin distinguishes two varieties of aural polypi : (1) The pale, œdematous polypi attached to the tympanic ring : removal of these polypi is free from the danger of setting up labyrinthitis. (2) The red vascular polypi arising from the inner tympanic wall : these may be associated with latent labyrinthitis. (*See* 'Treatment'.)

SYMPTOMS.—Granulations and polypi frequently do not produce any symptoms apart from those due to the chronic otorrhœa to which they owe their origin ; but in some cases a history of bleeding from the ear is given. Pain is not a common symptom and occurs only when there is retention of secretion. The amount of deafness varies greatly and depends largely upon the size of the growth and its position, as well as

upon the amount of destruction of tympanic structures caused by the original otitis media.

DIAGNOSIS.—This is usually made without difficulty. If there is much secretion, it may be necessary to syringe the ear in order to obtain a view of the deeper parts. On inspecting the ear after this has been done, a granulation appears as a red sessile growth, usually situated on the inner wall of the tympanum, and sometimes filling a perforation in the drum-membrane and apparently growing from it. In the case of granulations springing from the posterior meatal wall, it is usually possible by means of a probe to detect carious bone underlying the growth, or to locate the mouth of a sinus leading into the air-cells. A polypus may possibly be mistaken for an exostosis, or a red and bulged membrane ; if there is doubt as to the nature of the condition, the use of a probe will clear up the diagnosis. A polypus is characterized by its soft consistence and mobility, and by the fact that it does not spring from the meatal walls, but from the depths of the ear ; the exact attachment cannot be detected before removal. Polypi, if small, appear globular or pear-shaped, are usually attached by a pedicle, and are of a pink or red colour. As polypi and granulations may grow from the labyrinthine wall and may be associated with disease of its osseous capsule and contents, it is necessary to test both cochlear and vestibular reactions in all cases, lest by removal of a polypus a septic lepto-meningitis may be produced.

TREATMENT.—The treatment of granulations and polypi must be combined with that of the chronic suppuration in the middle ear. When cochlear and vestibular tests indicate that the labyrinth is involved, no attempt at treatment by way of the meatus is allowed. In other cases the line of treatment should be as follows :—

When there is very little granulation tissue, treatment may be confined to the

Fig. 193.—Neumann's method of producing local anæsthesia by the injection of a 1 per cent solution of novocain with adrenalin into the superior meatal wall.

instillation of rectified spirit each time that the ear is syringed. If the granulations are not destroyed, or are too plentiful to respond to such mild measures, they may be burnt by the application of solid silver nitrate or a chromic acid bead ; or they may be removed by means of a curette or ring knife. The electric cautery is very efficacious, but should be used only by one thoroughly conversant with the technique of intra-meatal operations.

When dealing with a polypus, the simplest and easiest method of removal is by means of an aural snare, such as Blake's, which is threaded with fine copper wire. An ordinary nasal snare can be adapted for this procedure. The ear may be anæsthetized by packing the meatus with a strip of self-edge gauze half an inch wide soaked in equal parts of 10 per cent cocaine and adrenalin, or by Blegvad's drops with adrenalin, or by Neumann's method (*Fig.* 193). The loop of wire, introduced through a speculum, is passed over the polypus and carried inwards as far as

possible. The wire is then tightened, and the polypus is withdrawn with a twisting motion (*Fig.* 194). A general anæsthetic, such as ethyl chloride or, better still, chloroform or ether, is advisable in the case of nervous patients, and always in children. There is generally free hæmorrhage, though this is much diminished by the use of local anæsthesia in addition to the general anæsthetic. When the bleeding has been stopped (this is done by packing the meatus), the ear must be inspected and, if the polypus has not been completely removed, the snare must be employed again, or the stump may be curetted with a ring knife or small sharp spoon. It may be necessary, owing to the hæmorrhage, to postpone the second part of the operation to a future occasion. In the after-treatment, in addition to syringing the ear, it is desirable to use spirit drops, either pure, or mixed with an equal quantity of peroxide of hydrogen in solution (10 vol.). On the whole it must be admitted that aural polypi usually recur after removal (75
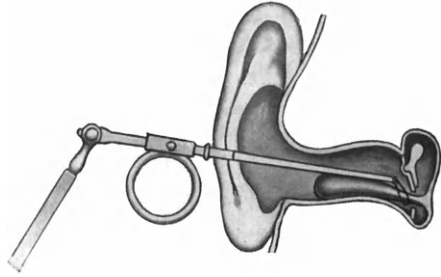
Fig. 194.—Removal of aural polypus with the cold wire snare.

per cent of cases), and that a radical mastoid operation is often required.

When granulations are associated with a sinus in the bone, their mere removal is of little use, as in a few days they grow as large as before ; this is an indication that more active interference is necessary, such as the performance of the radical or the modified radical mastoid operation.

FACIAL PARALYSIS.

Facial paralysis is not a very common complication of middle ear suppuration, and is more rare in acute than in chronic cases. It is especially liable to occur in tuberculous infections, and it is also common in malignant disease (*see* pp. 402, 409). Facial paralysis may be caused by cholesteatoma which erodes the bony covering of the nerve. It is sometimes produced by injury (concussion or hæmorrhage around the nerve sheath), or division of the nerve during an operation, and then it is observed when the patient recovers from the anæsthetic. If due to inflammatory reaction around the exposed nerve during the after-treatment, and not to division or serious injury, then the paralysis is not present immediately after the operation. Facial paralysis occurring in the course of a middle ear suppuration may be due to erosion of the bony canal in which the nerve is carried (aqueductus Fallopii), resulting in perineuritis ; or there may be a congenital dehiscence of the bony wall of the canal. The latter is usually the explanation of facial paralysis occurring in the course of an acute otitis media.

TREATMENT.—When facial paralysis occurs in the course of chronic suppuration, it is an indication for the radical mastoid operation, as

23

removal of carious bone and of any granulations surrounding the nerve will frequently be followed by recovery of function (*see also* p. 360).

CARIES OF THE OSSICLES.

Caries and necrosis of the ossicles may occur in chronic suppuration. It has already been stated that the ossicles are especially liable to destruction in otitis media due to the exanthemata.

Caries of the ossicles may be met with alone, or may be associated with caries of the temporal bone. The long process of the incus most frequently becomes affected, as its blood-supply is a poor one. Caries of the body of the incus, the head of the malleus, or even absence of both these ossicles occurs, but is not common.

Ossiculectomy, or removal of the malleus and incus, may be tried in cases in which caries is limited to the ossicles, and in which the hearing is considerably impaired ; also in cases of attic suppuration associated with a considerable degree of deafness. This operation has, however, gone out of favour, the reasons for this being : (1) It is generally impossible to say whether the caries may not involve the temporal bone as well as the ossicles, in which case another operation may become necessary. (2) The hearing after the radical operation is no worse than it is after ossiculectomy. (3) It has occasionally been found that cases which at first did well after ossiculectomy have returned later requiring the major operation.

MASTOIDITIS IN CHRONIC PURULENT OTITIS MEDIA.

SYMPTOMS.—In cases of chronic purulent otitis media, pain is a danger signal and is usually due to an acute exacerbation of the chronic suppuration. Pain is generally to be explained by the retention of secretion. More stress is, however, to be laid on the objective than the subjective signs ; but these vary in different cases, and depend largely on the position of the caries. The discharge is generally fœtid ; it may be abundant and creamy, or thin, blood stained and very offensive, and on microscopic examination may be found to contain myelocytes or osteoblasts. The presence of exuberant granulations which grow again with great rapidity after removal is very suggestive of caries ; they should be carefully probed, with the object of detecting bare or carious bone. Bulging of the posterior wall of the meatus is usually associated with cholesteatoma which has accumulated in the antrum and eroded the bony wall separating this cavity from the meatus. This may be followed by breaking down of the swelling and the formation of a sinus in the bone. Fistulæ may also be found behind the ear, leading to an aperture in the cortex of the mastoid bone. In some cases a large defect is met with in the outer wall of the attic, while in others facial paralysis develops.

DIAGNOSIS.—While in some cases the diagnosis of caries may be made with certainty from the signs detailed above, in those where the caries is deep-seated it is difficult to arrive at a definite conclusion. A history

of frequently recurring pain, an obstinate discharge which remains very fœtid in spite of treatment, and exuberant granulations which return rapidly after removal, all point to the presence of carious bone. In some cases it is possible to diagnose areas of necrosis in the mastoid process by changes in the shadow of the radiograph. Careful examination of the cochlear and vestibular apparatus should be made in all cases, as it assists the observer not only to locate the disease, but to apply correct treatment.

TREATMENT.—The presence of caries of the temporal bone is nearly always an indication for a mastoid operation, and as a rule the radical operation has to be performed. In cases of labyrinthine or intracranial involvement, this step should not be delayed, while no independent attempt should be made to interfere with any granulations which may be present. It depends on the severity of the condition whether it is allowable to temporize in the first instance, and limit the treatment to antiseptic measures and to such minor surgical procedures as the removal of granulations.

INDICATIONS FOR OPERATION ON THE MASTOID.

It is perhaps advisable to state, in the first place, that the presence of a long-standing chronic suppuration in the middle ear, unaccompanied by symptoms and in which the discharge is not fœtid, is not an indication for operation : first, because cases with central perforation of the drumhead are almost entirely free from the risk of intracranial complication ; and secondly, because it is impossible to promise that in all cases the discharge will cease after the mastoid operation. Certain *symptoms*, however, point to the necessity of operation, the most important of these being : —

1. Pain, associated, as a rule, with mastoid tenderness.
2. Vertigo, either constant or intermittent.
3. A temperature of over 100° F. in a case of middle ear suppuration.
4. Symptoms of an intracranial complication, such as headache, vomiting, rigors, etc. In these cases the radical mastoid operation is performed as a preliminary to further operative procedures.

The chief *objective signs* which afford an indication for operation are :—
1. A discharge which remains fœtid in spite of antiseptic treatment. In such cases the perforation is almost invariably a marginal one in the posterior part of the drumhead, or is situated in the lateral wall of the epitympanic cavity or attic. A radiogram may be of assistance (*Plate XVIII*, C, D, p. 338).
2. Granulations which recur rapidly after removal.
3. Subperiosteal mastoid abscess or sinuses in the bone which open on the surface or into the meatus.
4. Facial paralysis.
5. Cholesteatoma.
6. Stenosis of the meatus, or an exostosis interfering with proper drainage.

THE RADICAL MASTOID OPERATION.

The object of the radical mastoid operation is to convert the compli-
cated middle ear spaces into one common cavity freely communicating
with the enlarged external acoustic meatus.

The skin of the mastoid region is prepared as described under the
Schwartze operation (p. 340). A curved incision is made at the hair
margin, bending forwards at the lower end to the tip of the mastoid
process, and the flap thus formed is dissected forward till the retro-
auricular groove is reached (*Plate XXI*, A). The periosteum over the
process is then incised down to the bone, and the edges of the periosteal
wound are retracted to expose the mastoid cortex (*Plate XXI*, B), which
is then removed with the gouge and hammer, as previously described,
until the antrum has been opened (*Plate XXI*, C). (It is noteworthy
that in cases of chronic middle ear suppuration the mastoid process is
almost invariably (94 per cent) of the dense or sclerotic type, and that a
few small air-cells are met with only in
the lateral wall of the tympanic an-
trum.) In some cases the antrum itself
is so enlarged by the pressure of choles-
teatoma that the operation is rendered
an easy one ; indeed, the operation may
be found to have been already almost
completely performed by the choles-
teatomatous disease.

After the lateral wall of the tympanic
antrum has been freely removed, the
posterior bony wall of the meatus is
taken away with the gouge and hammer
(*Plate XXI*, D and E). The inner or
medial part of the posterior meatal
wall is known as the 'bridge' and
forms the lateral wall of the aditus.
This part has to be removed with some
care, in order to avoid injury to the
facial nerve and lateral semicircular
canal. The lateral or outer wall of the
attic is next removed by a blow or two of the gouge. The incus and
malleus, if present, can now be removed by Heath's forceps. The
auditory (Eustachian) tube is scraped out with Alexander's curettes,
which are quadrilateral on section and therefore fit the lumen of the
bony portion of the tube. All granulations or polypi in the tympanic
cavity are removed by means of a small sharp spoon, or forceps, care
being taken to avoid the region of the oval window and facial nerve.
The remains of the drumhead are also curetted from the tympanic ring
(*Plate XXI*, F). Bleeding from the bone can be controlled by Horsley's
wax which is put up in sterile tubes similar to catgut.

Meatal Plastic.—The cartilaginous meatus and the tube of skin which
lines the external auditory canal must now be dealt with. One method

Fig. 195.—Radical mastoid operation
(continued). Körner's meatal plastic.
The sharp-pointed tenotomy knife has
been passed through the external meatus
and is making the upper cut of the tongue-
shaped flap. The lower cut is indicated
by dotted lines.

PLATE XXI

RADICAL   MASTOID   OPERATION
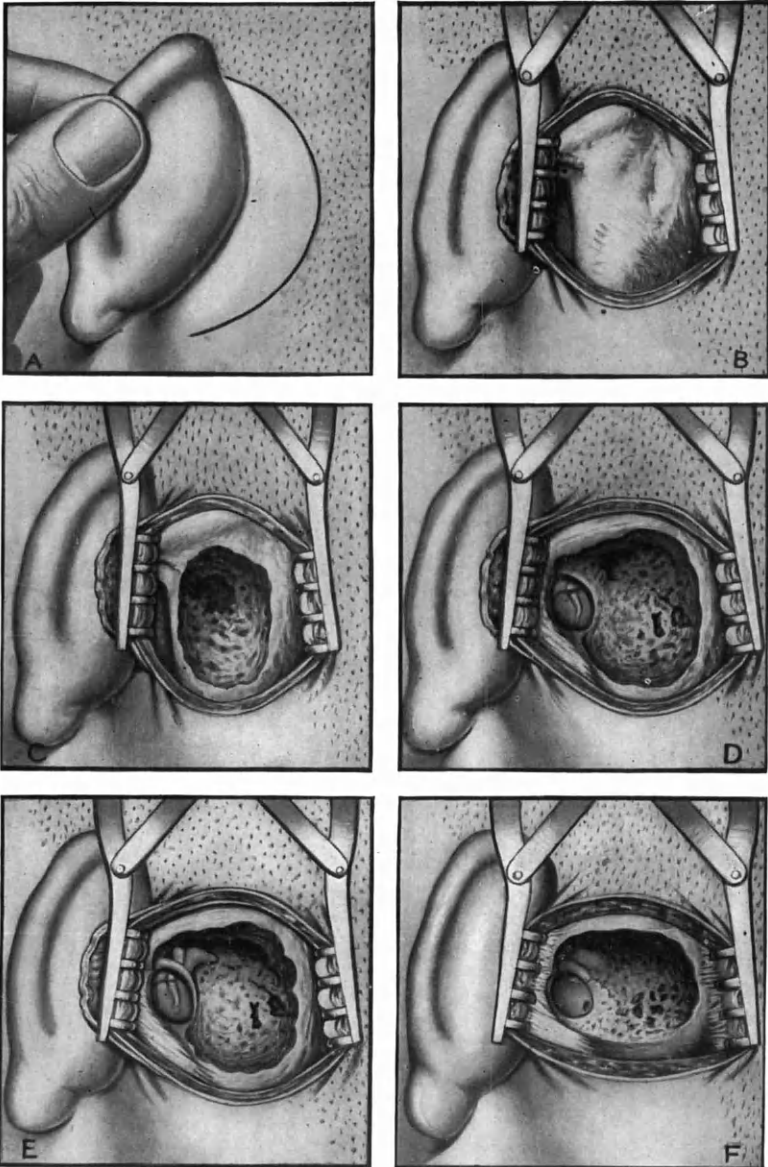
(A) Skin incision.   (B) Area of operation exposed.   (C) Mastoid antrum opened.   (D) Outer or lateral part of posterior bony meatal wall removed, but inner end, or bridge, remains. Drumhead is visible.   (E) Most of the bridge has now been removed, body of the incus and head of malleus are revealed.   (F) Radical operation completed.   Malleus and incus, with the drumhead, have been removed, Eustachian tube has been curetted, and facial spur lowered. Prominence of lateral canal. facial nerve, stapes, promontory, and the niche leading to the round window can all be seen on medial wall of operation cavity.

of doing so (Körner's) is shown in *Fig.* 195. An incision is made along the roof of the meatus with a sharp-pointed tenotomy knife passed into the external meatus. The incision is continued backwards into the concha. A similar incision is made in the floor of the meatus, so that a tongue-shaped flap is obtained. After the superfluous tissue on its posterior surface has been removed with scissors, the flap is tucked backwards and held in position by a mattress suture passed through the skin just behind the auricle. In order to make the opening larger, a small piece of the cartilage in the base of the flap may be dissected out and removed. Siebenmann's flap is shown in *Fig.* 196. It is necessary to deal with the meatus in this or a similar manner in order that, when the wound behind the ear has been stitched up, the whole of the operation cavity may be freely visible and available for after-treatment, through the enlarged external meatus. (During recent years some surgeons have performed the radical operation without cutting a meatal plastic flap.

The mastoid cavity is packed from behind for a few days, and later allowed to fill with blood-clot and granulations. The wound is then closed. The object of omitting the meatal plastic is to avoid the accumulation of wax and epithelial débris, which are apt to form in the large radical mastoid cavity. The objection to the method is the possibility, or rather the probability, of inadequate drainage of the antrum.)

After the cavity has been cleaned out, a little trimming with a gouge is necessary in order to lower the facial spur, i.e., the lower edge of the posterior bony meatal wall. In many cases the prominence on

Fig. 196.—Radical mastoid operation (continued). Siebenmann's Y-shaped flap.

the floor of the bony meatus must also be lowered so as to give access to the inferior part of the tympanum. The operation cavity is now swabbed out with peroxide of hydrogen and syringed with warm, sterile saline solution. The operation cavity may now be packed with iodoform gauze or worsted and the skin incision united with silkworm-gut suture or Michel's clips. Many otologists, however, prefer to line the cavity with a skin graft as this method shortens very greatly the healing of the cavity and almost abolishes the pain of the first dressing. The procedure is as follows : A Thiersch graft, four inches long and one and a half inches wide, is cut from the front of the patient's thigh with a dry hollow-ground razor (*Fig.* 197). The successful cutting of this graft requires a little practice. The graft is doubled over a piece of iodoform worsted, with the raw surface outwards (*Fig.* 198) and, after the packing in the operation cavity has been removed, is inserted into the depth of the wound. The ends of the graft are held by an assistant while the surgeon packs in iodoform worsted so as to bring the graft into apposition with all the raw bony surfaces of the operation cavity (*Fig.* 199). The ends of the graft are finally brought out at the enlarged external meatus

(*Fig.* 200), and the original incision over the mastoid process is united by means of six silkworm-gut sutures.   The ordinary dressings and bandage are then applied.   In order to prevent septic material accumulating between the graft and the medial tympanic wall, some
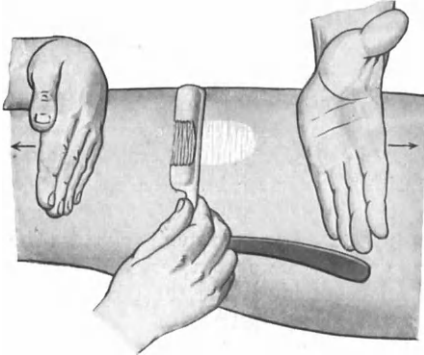
Fig. 197.— Radical mastoid operation (continued). Method of cutting the skin graft from the anterior and inner aspect of the patient's thigh.   The hand on the right of the figure is that of the assistant, who stretches the skin in the direction of the arrow.   The hand on the left belongs to the surgeon, who with his left hand stretches the skin in a downward direction while the right hand is used to cut the skin graft. An ordinary dry, hollow-ground razor is employed, with a rapid, saw-like movement.
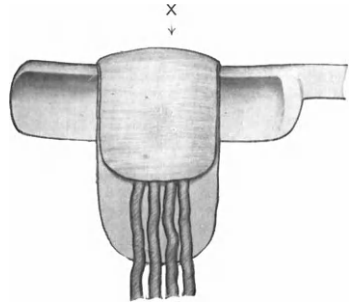
Fig. 198.—Radical mastoid operation (continued).   The skin graft is doubled over several strands of iodoform worsted. The upper part of the skin graft containing the iodoform worsted, marked X, is then grasped with angled aural forceps and inserted into the deepest part of the cavity formed by the radical mastoid operation.
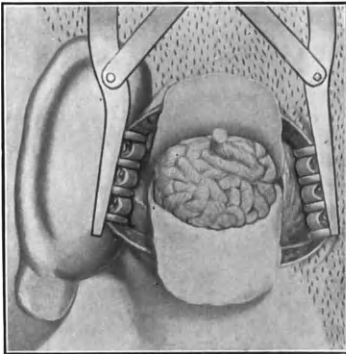
Fig. 199. — Radical mastoid operation (continued).   The upper and lower ends of the graft are held by an assistant while iodoform worsted is packed in so as to bring the raw surface of the graft into apposition with the walls of the operation cavity.
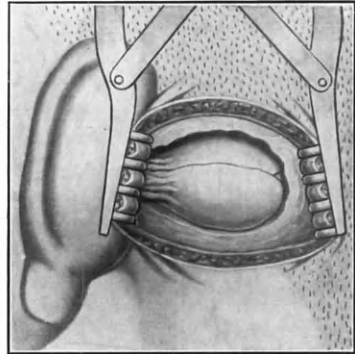
Fig. 200. — Radical mastoid operation (continued).   The outer ends of the graft are doubled over the iodoform worsted and brought out at the enlarged external meatus.   The wound is then closed with stitches.

surgeons cut a small hole in the graft which covers this important area.

If all goes well, the first dressing need not take place until the fifth day, when the stitches are removed and the iodoform worsted packing in the operation cavity is changed through the enlarged external meatus.

Fresh packing is inserted and allowed to remain in position for two days; but thereafter the cavity is left empty and the case treated by the wet method described for chronic middle ear suppuration (p. 347). The superficial layers of the skin graft separate slowly. Skin-grafting prevents contraction or stenosis of the operation cavity. The procedure is contra-indicated in cases of labyrinth fistula and of intracranial complication. As a rule patients are able to leave hospital at the end of fourteen days, though the cavity requires to be treated as above for two or three weeks more ; indeed, patients on whom the radical mastoid operation has been performed should always have the operation cavity syringed out at regular intervals of one or two weeks. If this is not done, wax and epithelium and even some pus tend to accumulate and give the impression that the operation has not been successful. Kolisch advises that in cases in which suppuration continues the cavity should be mopped out with insulin. Others advise lavage with 40 per cent Dakin solution. The persistence of Eustachian catarrh or suppuration is, however, the main source of failure after the radical mastoid operation.

As regards hearing after the radical operation, the following results may be mentioned : hearing improved, 48 per cent ; as before operation, 38 per cent ; hearing worse than before operation, 14 per cent.

Recently certain otologists have performed the radical mastoid opera-tion through the external acoustic meatus. Local anæsthesia is employed. The first step consists in cutting Körner's meatal flap which is brought out and held back by a stitch. A large aural speculum with a wide slot is then inserted and the bone of the posterior meatal wall removed with gouge and hammer and also with forceps. The operation is longer and more difficult and the only advantage is the avoidance of a scar behind the ear, which is not of importance.

Modified Radical Mastoid Operation.—The modified radical operation is reserved for : (1) Cases of chronic middle ear suppuration in which the hearing in the affected ear is fairly good, i.e., in which the conversation voice can be heard at four feet or more ; (2) Cases in which there is marked or total deafness in the 'other' ear ; and (3) Most cases of chronic middle ear suppuration in young children. There is no need to describe this operation in detail. It is only necessary to mention that, after the antrum has been freely opened, the outer part of the posterior bony meatal wall is removed, leaving the 'bridge' in position, with, of course, the tympanic membrane and ossicles (*Plate XXI*, D). In some cases of attic perforation with good hearing, the bridge and lateral wall of the attic are removed, but the ossicles and drumhead left (antro-atticotomy). The meatal flap is cut and stitched in position, the meatus and antrum being lightly packed with iodoform worsted, and the posterior wound closed.

Jenkins describes a form of attico-antrotomy : after under-cutting the skin a periosteal and muscle flap of triangular form is made with its base towards the pinna. The incus is removed and the apex of the flap tucked into the aditus. There is no meatal plastic.

Though the percentage of 'dry ears' after the modified operation (50 per cent) is not so high as that obtained after the radical operation (70 per cent), it is worth while to carry out the former procedure in

order to retain or improve the hearing. Watson found that the hearing distance was improved in 78 per cent of cases. If the modified operation is not successful, the 'radical' can, of course, be performed later.

The mortality associated with the mastoid operation in uncomplicated cases is less than 1 per cent, but in those with intracranial complications it is unfortunately very high.

Paralysis of the Facial Nerve after the Mastoid Operation.—If paralysis is present when the patient comes out of the anæsthetic, the condition is serious, as the nerve has almost certainly been cut or at least severely injured during the operation. There are now two policies which may be pursued : (1) To open up the wound, expose the cut ends by removal of bone, and place them in apposition. (2) To employ a nerve graft. Sir Charles Ballance and his colleague, Arthur Duel, demonstrated that autoplastic nerve grafts would restore the function of the injured facial nerve. They considered the anterior femoral cutaneous nerve the most suitable nerve from which a graft might be taken. Briefly, an incision is made five inches below the fold of the groin and one or other of the two branches of the anterior femoral cutaneous nerve at this point defined. The nerve is now divided, the distal end isolated and a piece of gold leaf is wound around it to ensure identification at the end of three weeks when Wallerian degeneration is sufficiently advanced. After the foregoing interval the facial nerve is exposed, working from the stylomastoid foramen towards the brain until the site of the injury is freely uncovered. The nerve sheath is now laid open by means of a very sharp knife exposing the nerve bundles when the site of the injury is widely excised and the prepared nerve graft from the anterior femoral cutaneous nerve is laid in such a manner as to bridge the gap. Gold leaf is again used as a dressing foundation. Some commencement of recovery of function may be expected in six or eight weeks' time.

Infection of the operative field is no contra-indication and heteroplastic grafts in individuals of the same blood group can be employed.

If the facial paralysis only comes on a few days after the mastoid operation, the trouble is not serious, as the paralysis passes off in the course of a few weeks.

Malignant Disease of the Middle Ear is dealt with in Chapter XL.

CHAPTER XXXVIII.

THE LABYRINTHINE AND INTRACRANIAL COMPLICATIONS OF SUPPURATIVE OTITIS MEDIA.

It is of great importance that practitioners should be conversant with the early symptoms and signs caused by the labyrinthine and intracranial complications of middle ear suppuration. Gardiner has analysed the cause of death in 8000 consecutive cases occurring in ten years at the Royal Infirmary, Edinburgh, and found that 142 of these (nearly 2 per cent) were due to the complications of purulent otitis media. Unfortunately many cases are not sent into hospital at the earliest possible moment. Cases of septic sinus thrombosis, with hectic temperature and rigors, have sometimes been treated with quinine because the cause of the symptoms (middle ear suppuration) was overlooked. In the same way, vomiting due to brain abscess has been treated by bismuth and hydrocyanic acid. Patients suffering from acute appendicitis or from ruptured gastric or duodenal ulcer are now diagnosed and placed as soon as possible in the hands of the surgeon and, mainly for this reason, the mortality has rapidly diminished. It is to be hoped that, in future and for the same reason, the death-rate in cases of sinus thrombosis, brain abscess, and even purulent leptomeningitis may show a similar decline. The importance of the early recognition of the labyrinthine and intracranial complications of middle ear suppuration can hardly be exaggerated, for the advances made in the last few years in the surgical treatment of these affections have been very gratifying ; recoveries have been recorded even in cases of purulent meningitis, a condition previously looked upon as invariably fatal. It is, however, only by early operation that success can be hoped for, and it is the duty of the practitioner to be on the look-out for the onset of an intracranial complication, and to call in the specialist while there is still a prospect of successful interference.

Routes of Infection.—From the middle ear and tympanic antrum infection may spread in the following directions :—

1. Medially to the labyrinth either through the oval or round windows or by erosion of the lateral semicircular canal. In rare cases the promontory may be eroded, especially in tuberculous disease.

2. Upwards towards the middle cranial fossa, resulting in extradural abscess or in abscess of the temporal lobe ; purulent leptomeningitis is a very rare complication from spread of infection by this route.

3. Backwards towards the posterior cranial fossa, producing (*a*) An extradural abscess between the sigmoid sinus and its bony wall or an abscess medial to the sinus, i.e., between the posterior surface of the petrous bone and the cerebellar dura mater; (*b*) Septic thrombosis of the sigmoid portion of the transverse (lateral) blood sinus ; (*c*) Purulent leptomeningitis beginning in the posterior cranial fossa ; (*d*) Cerebellar abscess.

4. Downwards through the floor of the tympanum, producing septic thrombosis of the bulb of the internal jugular vein. In rare cases downward spread of infection may lead to abscess formation below the petrous bone, resulting in retropharyngeal abscess.

LABYRINTHITIS.

Infection of the inner ear occurs in from 1 to 2 per cent of cases of purulent otitis media—usually as the result of an acute exacerbation in a chronic case. Labyrinthitis may be (1) *Circumscribed*, or (2) *Diffuse*.

The Circumscribed Form may affect only the bony capsule (paralabyrinthitis), or it may invade the perilymph space (perilabyrinthitis).
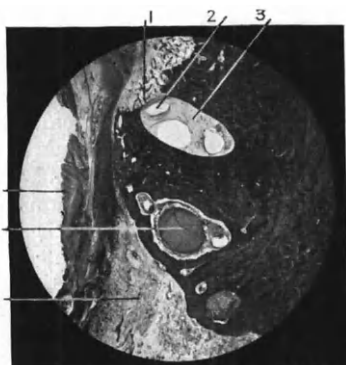
Fig. 201.—Chronic middle ear suppuration and cholesteatoma. Note erosion of bony prominence of lateral canal. (1) Erosion of bone over prominence of lateral canal (so-called fistula) ; (2) Endolymph space of canal ; (3) Perilymph space, largely filled up by new connective tissue ; (4) Granulation tissue on inner wall of tympanum below ; (5) Facial nerve ; (6) Cholesteatoma lining aditus and antrum.

These two forms may be combined. Circumscribed labyrinthitis is almost invariably associated with cholesteatoma, which erodes the bony prominence of the lateral semicircular canal on the inner wall of the aditus. (*See* CHRONIC PURULENT OTITIS MEDIA, pp. 346, 347).

Diffuse Labyrinthitis may be due to (1) the extension of the circumscribed form, but is more often due to (2) invasion of the inner ear by way of the oval or round window. The latter routes of infection are found especially in cases due to acute middle ear suppuration, invasion through the oval window being the most frequent path of entry. Diffuse labyrinthitis occurs in two forms, (1) empyema of the labyrinth (combined inflammation of the peri- and endolymphatic spaces), and (2) panlabyrinthitis, in which the bony capsule is affected in addition.

Diffuse labyrinthitis may be acute, subacute, or chronic. Labyrinthitis may also be classified according to the causal disease or organism—e.g., scarlatinal, cholesteatomatous, tuberculous, pneumococcic, etc. Fracture of the base of the skull, and injury with a pointed object such as a knitting-needle or unfortunate instrumental attempts at removal of a foreign body in the external meatus may cause a traumatic form of labyrinthitis.

Lastly, labyrinthitis may be classified according to the route of infection: (1) *Tympanic*, as in cases due to suppurative otitis media ; (2) *Meningeal*, as in cerebrospinal meningitis : from 15 to 50 per cent of cases of epidemic cerebrospinal meningitis result in deafness (*see* MENINGITIC NEUROLABYRINTHITIS, p. 417).

Tympanic Cases.—Ruttin points out that in acute middle ear suppuration œdema of the labyrinth wall may give rise to serous labyrinthitis ; a similar condition sometimes occurs after the radical mastoid operation.

Such 'induced serous labyrinthitis' usually passes off without calling for surgical treatment. In the more serious cases of tympanic origin the infection may pass from the middle ear to the labyrinth by way of : (1) The oval window ; (2) The round window ; (3) Fistula of the lateral canal ; (4) Fistula of the posterior vertical canal in cases of extradural abscess in the posterior cranial fossa : (5) Fistula through the promontory. If, for example, the prominence of the lateral canal is gradually absorbed by pressure of a mass of cholesteatoma in a case of chronic middle ear suppuration, in time the bone becomes worn through, so that the inflammatory process is now in direct contact with the endosteum lining the canal (*Fig.* 201). A little fibrinous exudation may occur in the canal in the region of this fistula (circumscribed labyrinthitis). The condition present in such a case corresponds to that in Ewald's experiment on the pigeon. If the air-pressure in the external meatus and middle ear is now artificially raised, pressure will be exerted through the fistula on the labyrinthine fluid, and therefore on the crista of the lateral canal ; giddiness and nystagmus are thus produced (fistula symptom). The hearing power is not affected, except by the otitis media already present. If now an acute exacerbation of the otitis occurs, the feeble barrier remaining may be broken down, so that the labyrinth becomes generally infected. At first the inflammatory exudation is serofibrinous, with only a few round cells (*diffuse serous labyrinthitis*), and if the process stops at this stage the labyrinth may almost entirely recover. Such a mild attack may occasionally follow the radical mastoid operation. On the other hand, if the inflammatory process continues, the labyrinthine fluid

Fig. 202.—From a case of acute purulent otitis media followed by purulent labyrinthitis and meningitis without rupture of the tympanic membrane. (1) Swollen, engorged, and infiltrated mucosa of 'tympanum ; (2) Pus in tympanic cavity ; (3) Footplate of stapes ; (4) Anterior crus of stapes —note that pus is entering the vestibule between the stapes and the margins of the oval window : (5) Pus in internal meatus ; (6) Saccule ; (7) Pus in vestibule ; (8) Hæmorrhage and pus ; (9) Utricle.

becomes definitely purulent (*manifest diffuse purulent labyrinthitis*) (*Fig.* 202) ; in this condition the patient suffers severely from giddiness, vomiting and loss of balancing. He complains that external objects appear to go round. He is absolutely deaf, but does not usually complain much of tinnitus. Within a few days (three to fourteen) the membranous labyrinth is entirely destroyed, and the condition passes into the stage of *latent diffuse purulent labyrinthitis*. This stage may last for several months, while granulation and connective tissue and, finally, new bone are formed in the labyrinth (*Figs.* 203 and 204).

The endosteum which lines the bony labyrinth is the most resistant of all the labyrinthine structures. In those cases of labyrinthitis in which spontaneous cure occurs, the organization of the pus in the labyrinth proceeds from this membrane ; osteoblasts pass into the granulation tissue which fills the labyrinth, and form new bone, until, eventually, the hollow spaces of the labyrinth may be entirely obliterated. The case thus passes into the stage of *spontaneous cure of labyrinth suppuration with compensation (Fig.* 204). Politzer points out that an abscess may form in the fundus of the internal meatus and destroy not only the nerve-fibres but also the labyrinthine artery ; this results in necrosis of the membranous labyrinth and of a large part of its cartilage-bone capsule.

Fig. 203. — Vertical coronal section through vestibule in case of chronic middle ear suppuration, with obliteration of tympanic cavity. The labyrinth was infected through the lateral canal. The pathological condition is one of latent labyrinthitis. (1) Vestibule filled with granulation and fibrous tissue ; (2) Facial nerve partially surrounded by connective tissue—the bony wall of the facial canal has been eroded ; (3) Cystic space in attic ; (4) Caries of promontory ; (5) Perforation of drumhead ; (6) Tympanic cavity almost obliterated by new connective-tissue formation ; (7) Round window membrane incorporated in new connective tissue ; (8) Jugular bulb ; (9) Footplate of stapes.

Fig. 204. — Horizontal section through labyrinth in case of chronic middle ear suppuration and old labyrinthitis. Hollow spaces of labyrinth are completely filled up by new bone formation. (1) Tympanic cavity—note that the radical mastoid operation has been performed ; (2) Position of vestibule, which has become filled up by new bone ; (3) Sinus tympani ; (4) Facial nerve, above stapedius muscle : (5) Probable position of posterior vertical canal, which is obliterated by new bone formation ; (6) Internal meatus ; (7) Position of cochlea, which has been replaced by somewhat spongy new bone.

COMPLICATIONS OF LABYRINTHITIS.

1. The inflammatory process may extend from the labyrinth by way of the aqueduct of the cochlea to the subarachnoid space of the posterior fossa and give rise to leptomeningitis.

2. The infection may spread to the internal auditory meatus within the arachnoid sheath of the cochlear nerve, or along the nerve to the saccule or utricle, and give rise to leptomeningitis.

3. Rarely pus collects in the endolymphatic sac (empyema of the saccus).

4. Cerebellar abscess may be associated with, or result from, labyrinth suppuration.

THE CLINICAL ASPECT AND TREATMENT OF LABYRINTHITIS.

Circumscribed Labyrinthitis and Labyrinth Fistula.—In this condition the patient complains of attacks of dizziness, with occasional vomiting,

especially on stooping or turning quickly. According to Ruttin, spontaneous nystagmus may or may not be present ; if present, it may be to the healthy side, to the diseased side, or even to both. If there is a tendency of the patient to fall, it is to the healthy side (Neumann). The caloric reaction is usually diminished. With the noise apparatus in the healthy ear, the patient can, as a rule, hear fairly well. Usually the fistula symptom is present (normal or reversed).

TREATMENT.—The radical operation should be performed, but great care must be taken not to interfere with the fistula. It not infrequently happens, however, that in spite of the greatest care diffuse labyrinthitis follows the radical mastoid operation in these cases. Further, if such a complication does not occur, the patient may continue to complain of attacks of dizziness even after the radical mastoid operation—attacks which interfere with his work. For these reasons the writer considers it advisable to perform the Hinsberg labyrinth operation (p. 366) in addition to the radical mastoid operation except in cases in which the hearing of the affected ear is very good indeed.

Diffuse Serous Labyrinthitis holds an intermediate position between circumscribed labyrinthitis and manifest diffuse purulent labyrinthitis.

SYMPTOMS.—The patient complains of deep-seated pain in the ear, tinnitus and deafness. The vestibular symptoms (dizziness, vomiting and loss of balancing) are more important. The patient lies on the sound and looks towards the diseased side, as in this position the nystagmus and giddiness are less. He complains that external objects appear to move from the diseased to the healthy side, or feels as if he himself were turning round. The temperature is not raised. With the noise apparatus in the sound ear the patient is not absolutely deaf. At the very onset of the affection the nystagmus is to the affected side, but, as this stage is of very short duration, such nystagmus is usually overlooked. Later, nystagmus is to the sound side ; e.g., if the lesion be on the left side, spontaneous nystagmus to the right is present ; when standing with eyes shut the patient tends to fall to the side of the lesion, i.e., in the direction of the vestibular component of the nystagmus—in this case to the left. If the patient's face be turned to the right he tends to fall forwards, while if it be turned to the left he tends to fall backwards. The vestibular reaction to rotation and syringing is usually still present, though diminished. The fistula symptom may be present, but is usually absent. Dench holds that there are only two tests which the otologist need employ : first, the use of the noise box of Bárány in the sound ear to ascertain the presence of complete deafness in the affected ear ; secondly, the caloric test of the diseased ear to ascertain the condition of the vestibular response. It is highly inadvisable to get the patient out of bed to demonstrate that he will fall in a certain direction on Romberg's test, and so on.

TREATMENT.—If the patient can still hear with the affected ear, the labyrinth operation should *not* be performed. If, on the other hand, the diseased ear is quite deaf and the vestibular reaction absent, the labyrinth must be opened and drained if and when the radical mastoid operation is called for ; in other words, if a diagnosis between diffuse

serous and diffuse purulent labyrinthitis cannot be made, the case should be treated as one of the more dangerous variety.

Manifest Diffuse Purulent Labyrinthitis.—This condition lasts only from three to fourteen days and is not associated with fever unless an intracranial complication is also present. During the earlier part of this period the patient suffers from intense giddiness, vomiting and loss of balancing. The vomiting is accompanied by nausea and is not of the effortless cerebral type. Complete deafness is present when the noise apparatus is sounding in the normal ear. Marked spontaneous nystagmus of the second or third degree is present to the sound side, and the caloric reaction is absent on the diseased side. Spontaneous pointing and falling are to the affected side. Later, however, this tendency to fall may only be noted if the patient tries to walk backwards or to hop with his eyes closed. The fistula symptom is not present, because the membranous labyrinth is destroyed. The patient is too ill for the rotation test. The symptoms and signs present are those of complete destruction of the affected labyrinth, and are due to the unopposed action of the other (healthy) labyrinth.

TREATMENT.—If there are no urgent symptoms, such as severe pain, fever, or signs of intracranial trouble, it is permissible to wait in order that a barrier may form. In cases of labyrinthitis arising in the course of acute middle ear suppuration and not associated with fever, headache, stiffness of the neck, exaggerated reflexes, and positive Kernig's sign, the patient should be kept absolutely at rest in bed for four to six weeks. On the other hand, when the labyrinthitis is due to (1) extension of a chronic purulent otitis media (mixed infection) to the inner ear, or (2) accidental injury of the labyrinth during the radical mastoid operation, or if (3) the early symptoms of meningitis are present, operation on the labyrinth should be performed.

There are two well-recognized types of labyrinth operation :—

1. *Hinsberg's*, in which, after the radical mastoid operation has been performed and the facial spur lowered so as to expose the promontory and niche of the fenestra cochleæ, the lateral semicircular canal is freely opened up behind the facial nerve and the promontory removed in front of the nerve by means of a small gouge, the stapes having been previously extracted.

2. *Neumann's* operation. (*Figs.* 205–8 show the anatomical relations of the parts concerned.) The radical mastoid operation again forms the preliminary step. Thereafter the dura mater of the posterior fossa over the sinus is laid bare with a blunt gouge (*Fig.* 206). The dura mater is then separated from the bone of the posterior fossa in a medial direction by means of a blunt dissector, and protected from injury with a small flat spoon or Stacke's protector. The petrous bone is now removed with the gouge and hammer in a medial and forward direction, until the posterior and then the lateral canal have been freely opened up behind the facial nerve (*Fig.* 207). The vestibule is now opened from behind by tracing up the smooth end of the lateral canal. By further removal of the projecting bone of the posterior wall of the petrous pyramid the lateral boundary of the internal meatus is taken away and its lining of

dura mater exposed. Finally, the vestibule should be opened in front of the facial nerve by two or three blows with a fine gouge, removing the promontory, and joining the oval and round windows (*Fig.* 208). Leidler states that the mortality of the labyrinth operation is 20 per
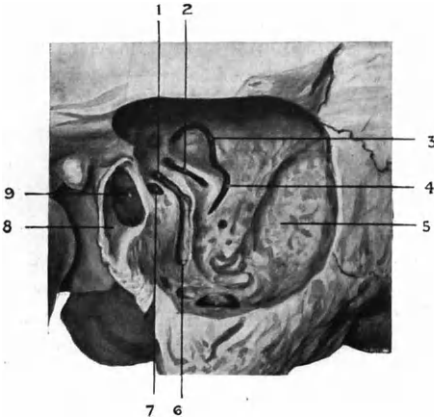
Fig. 205.—Anatomical relations concerned in dealing with the labyrinth. (1) Horizontal part of canal for facial nerve; (2) Lateral semicircular canal; (3) Superior vertical canal; (4) Posterior vertical canal; (5) Bony wall of sigmoid sinus; (6) Vertical portion of canal for facial nerve; (7) Oval window; (8) Anterior wall of bony meatus; (9) Promontory.
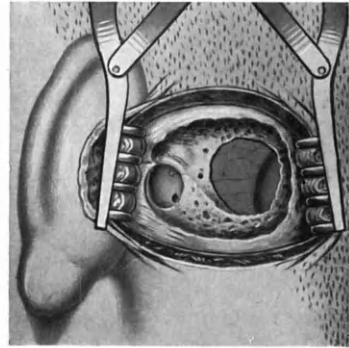
Fig. 206.—Neumann's labyrinth operation. After the radical mastoid operation has been completed, the sigmoid sinus is exposed and also the dura mater medial to the sinus. A further removal of bone in a medial direction opens up the posterior vertical canal.
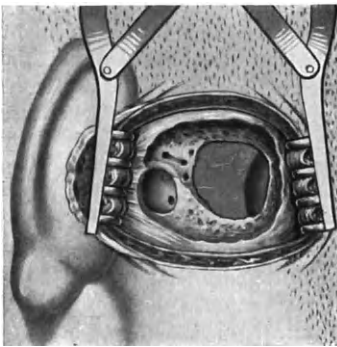
Fig. 207.—Neumann's labyrinth operation. Still further removal of bone opens up the lateral or horizontal canal.
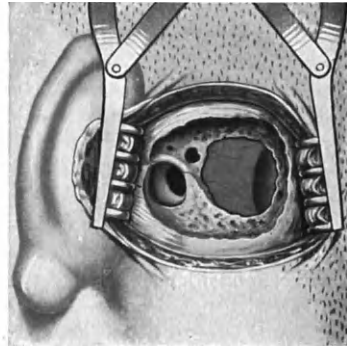
Fig. 208.—Neumann's operation. The smooth or medial end of the lateral canal is followed up into the vestibule, and, later, the promontory is removed by a gouge cut which joins the oval and round windows. The facial canal is seen intact between these two openings into the vestibule. The internal meatus is not yet opened.

cent. At present the general opinion is that the cochlea should not be further interfered with unless meningitis is present. In the latter case the medial wall of the vestibule should be opened up and the

subarachnoid space of the internal meatus drained (trans-labyrinthine drainage of West and Scott).

Latent Diffuse Purulent Labyrinthitis.—At the end of from three to fourteen days the manifest stage passes into that of latent diffuse labyrinth suppuration. The labyrinth is now entirely destroyed. The patient will, as a rule, if carefully questioned, give a history of recent dizziness, vomiting and loss of balancing, which symptoms have now passed off. In some cases, however, the onset of labyrinthitis is gradual, and the vestibular apparatus may lose its function without causing dizziness, nystagmus or disturbance of equilihrium.

SYMPTOMS.—There is complete deafness in the affected ear. Spontaneous nystagmus is usually absent, but there may be a slight rotary twitch to both sides. The caloric reaction is absent in the diseased ear. On rotation there is a marked difference in the duration of the 'after-nystagmus', depending on the direction of the rotation ; e.g., if the patient has a latent labyrinthitis on the right side, and if he is rotated to the right (thus mainly testing the left or healthy labyrinth), hori-zontal nystagmus to the left is produced of almost normal duration—say twenty seconds ; when, however, he is rotated to the left (thus mainly testing the right or diseased labyrinth), only very slight nystag-mus to the right is produced of from four to eight seconds' duration.

TREATMENT.—If the radical operation is called for, the labyrinth operation must also be performed. If this is not done, the patient runs a grave risk of meningitis as the result of the mastoid operation alone, which may cause the infection to spread from the diseased labyrinth to the meninges by way of the internal acoustic meatus.

Healed Labyrinthitis with Compensation.—This condition is probably present at a period of six months and upwards after the attack of purulent labyrinthitis. The patient is quite deaf in the affected ear, and the caloric reaction is absent. Rotation, however, to the right, and also to the left, produce an equal duration of 'after-nystagmus', because compensation has been established, and the lateral canal on the healthy side reacts equally to both directions of rotation. In such a case, even if the radical mastoid operation is called for, Alexander holds that it is not necessary to do the labyrinth operation, as there is no fear of infection spreading from the inner ear to the meninges. Other otologists, however, consider that it is impossible to be quite sure that the labyrinth is filled with new bone. They believe that pus may still be present, and that for this reason it is safer to do the labyrinth operation at the time when the radical mastoid operation is performed.

INTRACRANIAL COMPLICATIONS.

EXTRADURAL ABSCESS.

An extradural abscess consists in a collection of pus between the bone and the dura mater. Unless it is opened and drained, it is frequently followed by other intracranial complications. It is more common in the posterior than in the middle cranial fossa, i.e., extradural perisinus abscess and collections of pus in the posterior fossa medial to the sinus

are more common than pachymeningitis beneath the temporal lobe. Extradural abscess occurs more commonly in acute than in chronic middle ear suppuration ; of Blackwell's 35 cases, 29 were due to acute otitis media. In chronic purulent otitis media it is met with chiefly in cases of cholesteatoma and in acute exacerbations of chronic suppuration. The extent of the abscess varies greatly ; it may be quite small, or in chronic cases it may attain an enormous size.

SYMPTOMS.—The symptoms are rarely characteristic ; the majority of extradural abscesses are only discovered at the time of operation. The condition is associated with deep-seated boring pain, tenderness on tapping over the temporal lobe or posterior fossa, and rise of temperature. If the abscess is large, there may be evidence of compression of the brain. There are rarely any localizing symptoms, though occasionally paresis of the sixth nerve may be met with.

DIAGNOSIS.—This is not easy as a rule. The relief of pain by the spontaneous evacuation of a large quantity of pus, or the aspiration of much pus by rarefaction of the air in the external meatus (Politzer), will aid the diagnosis. The continuance of pain, pyrexia, and a raised pulse-rate after operation for a mastoid complication suggests the probability of the presence of a deeper-seated collection of pus.

TREATMENT consists in opening the abscess and evacuating its contents by free removal of the bony wall. When the abscess is opened the pus flows out in a pulsating manner. The affected dura mater may be covered with red 'healthy' granulations, or may be greyish-green and 'sloughy'. Removal of the overlying bony wall should be continued until the whole abscess cavity has been freely exposed. The operation wound is lightly packed with iodoform gauze or worsted and left open, i.e., unstitched. The Schwartze or the radical operation—according to circumstances—is performed at the same time. The patient should be carefully watched in order to detect the first signs of further intracranial complications, e.g., sinus thrombosis, brain abscess, or leptomeningitis.

LEPTOMENINGITIS.

In order to understand the changes which occur in meningitis it is necessary to discuss briefly the secretion, circulation and absorption of the cerebrospinal fluid. The fluid is secreted mainly by the choroid plexuses of the cerebral ventricles. Starting in the lateral ventricles, the fluid flows through the foramina of Monro to reach the third ventricle. Here its volume is augmented by the choroid plexus of that cavity ; it then passes through the aqueduct of Sylvius into the fourth ventricle. The fluid now passes out into the cisterna magna of the subarachnoid space through the minute foramina of Magendie and of Luschka, which perforate the lower part of the ventricular roof. From the cisterna magna the fluid permeates upwards and forwards round the sides of the medulla and over the cerebellar hemispheres. In order to reach the fore-brain it must pass through the narrow isthmus of the subarachnoid space which surrounds the mid-brain and is bounded by the free edges of the tentorium cerebelli and the basisphenoid. (This accounts for the accumulation of pus so often found between the upper surface of the

24

cerebellum and the lower surface of the tentorium.) The roomiest part of this passage is the cisterna interpeduncularis, from which the fluid ascends over the cerebral hemispheres. The fluid, after escaping from the ventricular system through the foramina of Magendie and Luschka into the cisterna magna, also passes caudally into the spinal theca—the most convenient anatomical site at which to obtain fluid for investigation, i.e., by lumbar puncture. ' The cisterna pontis and the cisterna lateralis—which contain the seventh and eighth nerves—communicate freely with the cisterna magna. (Infection in the region of the internal acoustic meatus may, however, remain localized for a short time. This fact is of importance in the treatment of meningitis following labyrinthitis.) Absorption of cerebrospinal fluid takes place almost entirely from the subarachnoid space overlying the cerebral hemispheres. The return to the blood-stream of the fluid is the function of certain specialized structures derived from the arachnoid membranes—the arachnoid villi and the Pacchionian bodies, which perforate the dura mater and project into the cranial sinuses and larger cerebral veins. It will thus be seen that a meningitis commencing on the posterior surface of the petrous bone tends to be confined, for a time at any rate, below the tentorium, and only spreads slowly upwards along the Sylvian fissure.

Greenfield states that the cells of the choroid plexus form a selective barrier between the blood and the cerebrospinal fluid, allowing certain substances, e.g., chlorides and magnesium, to pass freely, and keeping back others, e.g., protein. When, however, there is widespread meningeal inflammation, the barrier between blood and fluid becomes less complete and the chemical composition of the cerebrospinal fluid approximates to that of the blood. Glucose in the cerebrospinal fluid tends to disappear, due to the putrefactive action of bacteria. So long as the meningitis is limited to a small area, the percentages of the inorganic salts in the fluid remain unaltered, even though the fluid be turbid with pus-cells and contains an excess of protein, whereas when the meningitis becomes more widespread, the chlorides and magnesium are diminished. Dyes, such as methylene blue, pass into the cerebrospinal fluid much more readily when meningitis is present.

Leptomeningitis may be serous or purulent, localized or diffuse, and may run an acute or a chronic course. It may be the result either of acute or chronic suppuration in the ear. (1) The infection may pass through an erosion of the bone situated in the groove of the transverse sinus, or the posterior surface of the petrous bone—more rarely in the roof of the middle ear. (2) It may also arise, in the absence of defects in the bone, by infection through the inner ear and internal auditory meatus and perilymphatic aqueduct or (3) along the sheaths of the vessels which run between the middle ear and the meninges, e.g., those which pass from the inner wall of the tympanic antrum to the fossa subarcuata and posterior cranial fossa. (4) Lastly, infection may come through the blood-stream in septicæmic cases.

Jenkins points out that meningitis may be compared with other forms of pyogenic infection, such as abscess formation in the subcutaneous tissues, in which there is in the centre a collection of pus. Outside this

there is a zone of dead tissue, with dead and dying polymorphonuclear leucocytes and organisms. Beyond this there is an advancing line of organisms, and outside this again an area of altered connective tissue cells, plasma cells, and lymphocytes. We can thus understand how in early cases pus may be present around the internal acoustic meatus though the fluid obtained by lumbar puncture may still appear clear at least to the naked eye. There are two degrees of septic meningitis : (1) In which the organisms have not reached the internal surface of the arachnoid, e.g., extradural abscess ; and (2) In which they have invaded the subarachnoid space. The dura mater, arachnoid and pia mater are all resistant to infection. In very severe cases the superficial layers of the brain itself are infected and the condition is one of meningo-encephalitis.

Circumscribed Serous Meningitis in the Middle Cranial Fossa (Gradenigo's Syndrome) (*see* INFLAMMATION OF THE CELLS AT THE APEX OF THE PETROUS PYRAMID, p. 342) is occasionally met with in otitis media. The anatomical explanation of the syndrome is as follows : For a few millimetres the sixth nerve lies in a groove at the apex of the petrous portion of the temporal bone beneath the firm petroclinoid ligament. Even a small inflammatory exudate at this point may interfere with the function of the nerve.

Circumscribed Serous Meningitis in the Posterior Fossa (Bárány's Syndrome).—After an acute otitis media, and occasionally after the radical mastoid operation, the patient may suffer from giddiness, pain at the back of the head, deafness and tinnitus. Examination reveals deafness, vertigo and nystagmus most marked on looking to the healthy side. There is also falling and past-pointing to the diseased side, with occipital headache. Many of the patients show an hysterical tendency. Optic neuritis may or may not be present, but the cerebrospinal fluid is normal. Bárány considers the condition most probably one of localized collection of fluid in the cisterna pontis. Patients may have a sudden feeling as if something had burst at the back of the head, followed by immediate disappearance of the symptoms. Bárány, who finds the symptom complex present in some cases in which there is no history of otitis media, recommends lumbar puncture, or, in obstinate cases, exposure and opening of the dura mater of the posterior fossa. An iodoform gauze drain may be left *in situ* for a week. In a similar case Colledge trephined the occipital bone. The cerebellum bulged into the wound and, when this was displaced with a spatula, there was a gush of cerebrospinal fluid. The cerebellum collapsed and cure resulted.

Diffuse Serous Meningitis differs from purulent meningitis only in degree ; indeed, it must be regarded as a preliminary stage of the more dangerous form, and is sometimes associated with extradural abscess and other intracranial complications. The symptoms are fever, headache, drowsiness, slow pulse and vomiting. Optic neuritis may be present. On lumbar puncture the fluid is clear, but under considerably increased pressure. A definite diagnosis must often be delayed until the effect of treatment has been observed ; if cure results, the meningitis was probably serous.

Diffuse Purulent Leptomeningitis.—The first sign of meningitis in a case of labyrinthitis is slight torpidity, without irritability (Jenkins). This stage may have been recognized by the patient's friends. J. P. Stewart finds that males are affected in 75 per cent of cases, and that the patient has a premonition of his impending fate and exhibits an unnatural anxiety as to his prospect of recovery and return home. As a rule, he is slightly confused. The temperature is usually between 100° and 101° F., and the patient suffers from frontal or occipital headache, with tenderness and rigidity of the muscles at the back of the neck. This is most easily tested by lifting the patient's head off the pillow or by pressure over the atlanto-occipital membrane. In the earlier stages of meningitis arising from extradural abscess in the posterior cranial fossa the symptoms are not definite. There may be an initial rigor. Pain is localized at first to the side or back of the head, but later becomes general. Accompanying the headache are fever, restlessness, and marked irritability of temper ; vomiting is often present, and the tongue is heavily coated, and the teeth covered by sordes. The patient frequently lies with his knees drawn up and head turned away from the light (photophobia). Periods of excitement come on at times, during which he may cry out or talk incoherently. Ruttin points out that in meningitis the strength of the cry gradually increases, whereas in brain abscess the cry is strongest at first and tails off as the patient relapses into a semi-comatose condition. Delirium is common in children and convulsions are not infrequent. Herpes labialis may be present. Occasionally severe pain in the back is complained of. The reflexes are increased and, especially in children, the abdomen is retracted. An inability to extend the knee when the thigh is flexed (Kernig's sign) is generally present. The temperature rises sharply and remains elevated (103° to 104° F.) and towards the end may rise to 106° or 107° F. The pulse, at first strong, and slow (vagal stimulation) considering the presence of fever, soon becomes weak and fast (vagal paralysis), and the blood-pressure becomes very low. Blood examination usually shows a leucocytosis of about 20,000. (In meningitis arising in the middle cranial fossa, headache and fever may be the only symptoms, or the case may closely resemble one of temporal lobe abscess.) In the final stages paralysis may develop, and may affect various parts of the body and also some of the cranial nerves, especially the third and sixth with the production of squinting. Optic neuritis is frequently met with, while the pupils are contracted and equal and react sluggishly. Coma supervenes before death.

DIAGNOSIS.—Meningitis must be diagnosed and treated at an early stage, if surgical intervention is to have a reasonable chance of success (Jenkins). Neumann recommends a diagnostic lumbar puncture in cases of high temperature alone. There are a few cases on record of recovery from septic meningitis even after micro-organisms have been found in the cerebrospinal fluid, but these cases are only exceptions to a very general rule that meningitis, when it reaches this stage, is fatal. The progress of the case depends as much on the resistance of the individual to the organism and its toxins as on the nature of the organism. The

character of the cerebrospinal fluid at the point of maximum infec-
tion is not necessarily represented by the sample obtained on lumbar
puncture.

Meningitis is often combined with other intracranial complications.
When meningitis is suspected, lumbar or cisternal puncture should be
carried out, as it often gives a great deal of information. It is important
that there should be no blood in the fluid sent for examination, and there-
fore the first few drops should be allowed to escape. The sterilized
tube should have a rubber cork and the lumbar puncture needle should
be free from lysol. As regards the cerebrospinal fluid, 4 cells per c.mm.
may be regarded as normal. If the fluid is under tension, but clear
and sterile, and the cell elements on examination are not found to be
increased, the meningitis is still at the 'serous' stage ; on the other hand,
if the fluid is under pressure and is turbid from the presence of leucocytes,
purulent meningitis may usually be diagnosed. If organisms are present
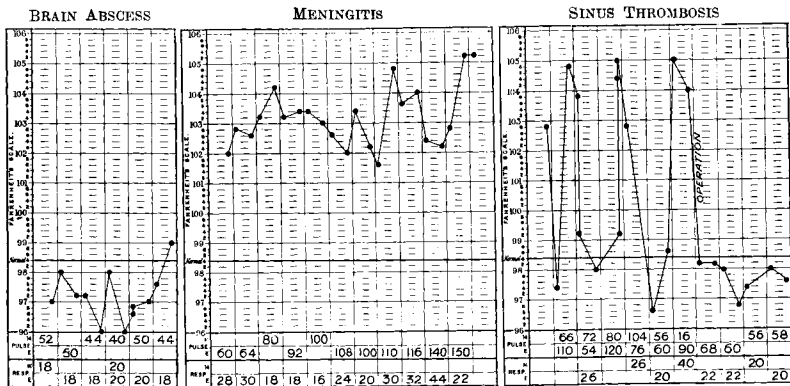
Fig. 209.—Charts showing characteristic temperature and pulse-rate in various intracranial
complications of middle ear suppuration.

in addition to pus-cells, there can of course be no doubt. Too much
stress should not, however, be laid on the changes found in the cerebro-
spinal fluid obtained by lumbar puncture. The fluid may be clear and
sterile even in purulent meningitis, especially if localized to the middle
cerebral fossa. The fluid may be turbid though sterile when a brain
abscess is present. Normal cerebrospinal fluid contains 0·5 per cent
of globulin : in meningitis this is increased. The normal limits of
glucose vary from 0·045 to 0·085 per cent. If sugar be diminished or
absent there is microbic invasion of the cerebrospinal fluid. From
0·72 to 0·75 per cent of chlorides are regarded as normal. If the chlorides
fall below this the prognosis is very grave (Rosher). The temperature
curve in uncomplicated meningitis is of considerable diagnostic import-
ance, as it maintains a consistently high level. In sinus thrombosis
the temperature is hectic, showing rapid rises and equally rapid falls,
and in brain abscess it is often subnormal (*Fig.* 209). The diagnosis
is frequently complicated by the presence of two or more intracranial

lesions, e.g., thrombosis of the transverse sinus or abscess of the brain (*see* below and p. 389).

PROGNOSIS.—Meningitis ends fatally in the great majority of cases (93 per cent, Stewart). The prognosis in children under 5 and in adults over 30 is specially bad. Mygind states that between the ages of 15 and 30 half his cases recovered. Meningitis due to chronic suppurative otitis media is more favourable than that due to the acute form, while meningitis following labyrinthitis is of specially bad omen unless promptly treated. Cases in which polymorphonuclear cells are in the majority in the cerebrospinal fluid are less favourable than others. In cases associated with brain abscess it is not uncommon to obtain a turbid cerebrospinal fluid on lumbar puncture, though there is little clinical evidence of meningitis : on culture the fluid proves to be sterile. Greenfield lays stress on the percentage of chlorides in the fluid, and holds that if these remain at their normal level the case is likely to recover. Further, in cases associated with sinus thrombosis the prognosis is better than in those with brain abscess.

TREATMENT.—Neumann states that " Otosurgery in meningitis to be successful must be in the very early stages and more from the viewpoint of prophylaxis." He strongly advises the most radical removal of all diseased tissues and the consequent exclusion of all transmission passages. Therefore if meningitis proceeds from an acute mastoiditis then the mastoid bone must be removed. The first step consists in opening up and removal of all cell groups, next the roof of the external meatus, the lateral wall of the attic and the bony roof of the middle ear, damaging the ossicles as little as possible. The upper pyramidal wall is inspected after elevating the dura mater that covers it. The dura mater of the middle cranial fossa is exposed in its entirety and thus we have it laid bare over the mastoid process, antrum, and middle ear, as far as the tubal orifice. A very generous exposure of the posterior cranial fossa is made, so that one has an opportunity of inspecting the posterior surface of the pyramid and also the region of the jugular bulb. Finally after careful elevation of the dura mater containing the superior petrosal sinus from off the free edge of the pyramid ; the bone containing the groove for the superior petrosal sinus is also removed. This last manœuvre is facilitated by the complete removal of the petrosal angle cells and the consequent diminution in size of the bone forming the junction at which the inner plates of the middle and posterior cranial fossæ meet at right angles. In this operation the middle ear and its structures are spared.

If labyrinthitis and meningitis are present in a case of acute or chronic middle ear suppuration, the radical operation should be carried out and followed at once by the labyrinth operation and translabyrinthine drainage (*see* p. 366). If no flow of cerebrospinal fluid can be established from the fundus of the internal auditory meatus, the dura mater of the cerebellar fossa, as exposed by the Neumann operation, must be incised and the cisterna pontis opened and drained by a gauze wick.

Recently air or sometimes acetylene has been insufflated into the spinal canal after the removal of a corresponding amount of cerebro-

spinal fluid. The gases are reported to retard agglutination, dilate the ventricles and keep patent the passages, thus enabling the liquor to circulate freely. (Otto Mayer.)

Daily lumbar punctures lessen the headaches.

The ' medical ' treatment of meningitis appears to be of little value and therefore no useful purpose can be achieved in elaborating it here.

ABSCESS OF THE BRAIN.

An otitic brain abscess is usually found close to the disease which causes it (McBride, Körner), and is therefore situated, in the vast majority of cases, in the temporal lobe (*Fig.* 210) or in the cerebellum (*Fig.* 211) of the diseased side, the former being the more common according to most authorities. An otitic brain abscess is usually single, though more than one may be present. The abscess may be acute, i.e., without a definite capsule especially in cases in which the abscess results from acute middle ear suppuration. Chronic abscesses have a more or less definite capsule.

Meningeal abscess formation may occur—either subdural or between the pia and arachnoid. Such collections of pus may be regarded as a protective process which tends to prevent general infection of the meninges (Eagleton). Brain abscess occurs as a rule between the ages of ten and thirty ; it is commoner in males than females, and is more frequently the result of chronic than of acute suppuration. In chronic cases cholesteatoma is usually present in the middle ear spaces.

Cerebellar abscess is due to : (1) Extension of infection from the mastoid process posteriorly and medially, through the triangular area (Trautmann's) bounded above by the superior petrosal sinus, below and in front by the facial nerve, and behind by the sigmoid sinus : this is the most frequent route of infection, and as a rule an extradural abscess precedes the formation of the cerebellar abscess which is situated in or near the anterior surface of the cerebellum. (2) Septic thrombosis of the sigmoid sinus which is usually associated with an extradural perisinus abscess. (3) Labyrinthitis in cases of chronic middle ear suppuration. As the cerebellar abscess grows it may produce internal hydrocephalus and 'corking' of the brain stem.

Temporal lobe abscess is caused by the spread of the infection through the tegmen tympani vel antri.

Abscess of the brain is frequently preceded by extradural abscess. The dura mater, pia arachnoid membrane and brain become adherent, and, an area of encephalitis or red softening having formed first of all, the abscess develops in close relation to the extradural abscess. More rarely the abscess is due to septic infection of one of the pial veins of the temporal lobe or cerebellum. Infection by this route, which is common in cases of acute middle ear suppuration, may result in multiple abscesses and meningitis.

When once it has formed, a brain abscess tends to expand at the expense of white matter, which has less vascularity than the grey. In the temporal lobe an abscess spreads along the vessels towards the lateral ventricle (Miles Atkinson).

SYMPTOMS.— A brain abscess may be divided clinically into four stages :—

1. *Initial.*—There may be an initial rigor, with headache, vomiting and rise of temperature during the period of red softening. This stage lasts for a few days and is usually preceded by stoppage of the aural discharge.
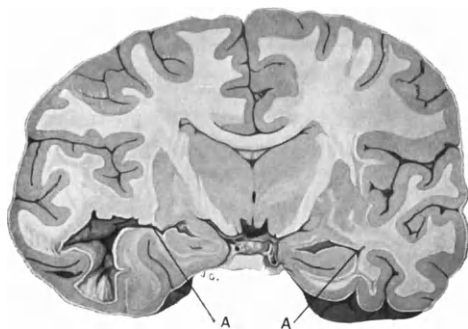
Fig. 210.—Abscess of left temporal lobe. Note that the abscess has ruptured into the left lateral ventricle. (A) Lateral ventricles.

2. *Latent.* — During the latent stage, of variable duration, there are no marked symptoms, though the patient's mentality may change. He may be irritable and moody, and there may be more or less headache. Constipation and loss of weight are present in cases of chronic brain abscess but at times the patient feels fairly well and may continue his work.

3. *Manifest.*—In this stage the symptoms are in part due to (*a*) compression of the brain, and in part to (*b*) toxæmia resulting from the suppuration. (In addition there may be localizing symptoms depending on the part of the brain affected. These are dealt with later.)

a. Symptoms due to compression are headache, nausea, vomiting of the projectile type, slow pulse and subnormal temperature (*see Fig.* 209). Optic neuritis is frequently present and is usually more marked on the diseased side. Headache is one of the earliest symptoms and lasts as long as consciousness

Fig. 211.—Cerebellar abscess. (1, 1) Indicate what would be the normal middle line of cerebellum and pons—note the swelling of the cerebellar hemisphere containing the abscess ; (2) Opening made for drainage.

persists. Nausea and vomiting are unconnected with the ingestion of food and may recur several times a day. In many cases of brain abscess the patient has a ravenous appetite—a symptom not infrequently associated with a favourable prognosis. The pulse, at first rather quick,

gradually becomes slower, and may drop to 40 or 50. The temperature also becomes subnormal unless the condition is masked by coexisting meningitis or sinus thrombosis ; but even in these cases the pulse remains relatively slow. The patient is drowsy and his cerebration slow. He may have to be shaken gently before he answers a question, and relapses almost at once into his former semicomatose condition.

b. The symptoms due to the suppurative process are rapid exhaustion and very marked emaciation ; there is also a peculiar and very disagreeable odour of the breath. The appetite is poor, the tongue thickly furred, the patient pale and constipated, and sordes form on the teeth. A blood-count usually shows a well-marked leucocytosis. On lumbar puncture the fluid may be quite normal but more frequently there is an increase in the cells—chiefly small lymphocytes. Even when the fluid is turbid it is usually sterile.

4. *Terminal.*—The terminal or paralytic stage is associated with coma and sometimes with convulsions.

DIAGNOSIS.—While in many cases it is possible from the signs and symptoms described above to say with some degree of certainty that a brain abscess exists, it is much more difficult, and sometimes impossible, to locate it, for there may be no focal symptoms. There are, however, certain signs which, if present, point to a definite situation of the abscess.

Abscess in the Temporal Lobe.—Localized headache over the temporal lobe may be present, and the patient may claw uneasily at the affected region. Tenderness on tapping over the temporal region is found in cases in which an extradural abscess is also present. Paresis of the third nerve is often present on the side of the lesion and is indicated by dilatation of the homolateral pupil. Ptosis may develop later, followed by paralysis of the external muscles supplied by the third nerve. Not uncommonly there are contractions of the facial muscles on the side of the lesion, especially of those concerned in wrinkling up the skin of the forehead and in frowning. When spoken to, the patient may repeat the same word over and over again—a condition known as 'perseveration.' Not infrequently his friends notice a change for the worse in his character. When the abscess is sufficiently large to cause pressure on the internal capsule, paresis may develop in certain of the groups of muscles of the opposite side of the body, and even hemiplegia may arise. In such cases there is dorsiflexion on eliciting the plantar reflex. Crossed deafness and crossed facial paralysis sometimes occur. Dan McKenzie and also Just have recorded cases of encephalitis of the temporal lobe associated with convulsions. *If the abscess is situated on the left side, optic aphasia is frequently found,* but is a late symptom and by no means constantly present. The purulent collection interferes with the nerve-tract connecting the centres for visual and auditory memory. Thus the patient is unable to name such simple objects as a pen, knife, or keys, though he may demonstrate by pantomime that he knows how to use them. It will thus be seen that an abscess of the left temporo-sphenoidal lobe is more easy to diagnose than one on the right side. Indeed in cases of bilateral purulent otitis media with well-marked general symptoms of brain abscess it may only be possible to diagnose

the presence of the abscess in the right temporal lobe by finding that the localizing symptoms of abscess in the left temporal lobe and those of abscess in both lateral cerebellar lobes are absent. Symonds states that the most important signs of abscess of the temporal lobe are slight weakness of the opposite side of the face in its lower half, most obvious when the patient talks or smiles, and absent or diminished abdominal reflexes, with increased knee-jerk and extensor or doubtful plantar response on the contralateral side due to pressure of the abscess on the pyramidal tract. Paralysis of the contralateral arm and even of the lower extremity have been described. Anosmia may sometimes be detected, but it is a symptom which may readily escape notice unless specially looked for. Homonymous hemianopsia may be present if the abscess is large and extends towards the optic radiation. Symonds and Cairns recommend perimetry on the Bjerrum screen but the rough test with the fingers is sometimes sufficient. The usual type of defect is in the superior quadrant. When the patient is alert this sign is easily demonstrated, but when his mental state is impaired Edwin Bramwell states that it is necessary to take the patient by surprise. The observer stands opposite to the patient and makes certain that he (the patient) is looking directly at him. The observer then raises a finger on either side of the patient's face, on a level with the eyes, and says sharply, " Take hold of my finger ". If the patient makes no response he is probably incapable of understanding. If he raises both his hands and grasps each of the observer's fingers, it is evident that there is no gross temporal hemianopia. If, however, the patient only raises one hand to grasp one finger, it is then obvious that he does not see the other finger. This method is also of use in the case of young children. A radiogram may aid the diagnosis as brain abscesses sometimes contain gas which can be shown by X rays. Nystagmus is very rare in temporal abscess, and only occurs if the sup- puration extends backwards to the occipital lobe. *Sudden onset of coma with high fever indicates that the abscess has ruptured into the lateral ventricle (see Fig.* 210). In cases of localized collection of pus on the surface of the brain, beneath the pia arachnoid membrane, there may be a sudden onset of Jacksonian epileptic attacks on the contralateral side.

    Cerebellar Abscess.—The patient generally lies curled up, his head turned towards the side of the lesion. When sitting up or standing he tends to hold his head inclined to this side. Often there is considerable rigidity of the neck. The patient complains of dizziness when sitting up, and when erect he stands with a wide base. Though the headache is usually occipital it is well to remember that in cerebellar abscess there may be complaint of headache in the frontal region. Milligan mentions yawning and hiccup as symptoms suggestive of pus in the posterior cranial fossa. The speech may resemble that in disseminated sclerosis, i.e., scanning speech. Vomiting and optic neuritis are more common in cerebellar than in cerebral abscess ; cerebellar ataxia may also be present, the patient staggering or falling towards the diseased side as a rule. Further, the direction of the fall on Romberg's test (backwards and to the diseased side) is not influenced by cold syringing of the ear or by altering the position of the patient's head. As cerebellar control

is homolateral, the signs of cerebellar abscess are on the same side as the lesion. Movements of the homolateral limbs are asynergic, and the patient is disinclined to use the limbs on this side when he is irritated, e.g., by holding his nose (Mann). The deep reflexes may be increased on the side of the lesion. A valuable localizing sign is 'dysdiadoko-kinesia' (Babinski). In testing for this, the forearms are alternately and quickly pronated and supinated; if the sign is present, fatigue is rapidly induced in the arm on the diseased side. When the patient raises both hands in the position of taking an oath he is unable to hold them there; both arms drop suddenly, the one on the affected side oscillating considerably as it falls. Nystagmus is usually present, and is coarser and of greater amplitude than that due to labyrinthitis; it is generally directed towards the affected side, and becomes more noticeable as the disease progresses (see FUNCTIONAL EXAMINATION OF THE EAR, p. 291). The variability of the nystagmus of cerebellar abscess is characteristic. At one time it is directed to the affected side and at another to the sound side, or it may be absent for short periods. This is in marked contrast to the conditions found in labyrinthitis, in which the nystagmus is always directed to the healthy side and gradually diminishes in intensity, passing from the third to the second, and later to the first, degree before disappearing. It will thus be seen that in labyrinthitis the symptoms and signs gradually diminish and pass off, whereas in cerebellar abscess they show a progressive increase. In the diagnosis of cerebellar abscess the pointing test, as suggested by Bárány, may be found useful (see p. 291).

Fig. 212.—Exposure of dura of middle cranial fossa on left side preliminary to drainage of temporal lobe abscess.

In cerebellar abscess there is usually deviation in the pointing test, and as a rule it is outwards on the side of the lesion, but, like the nystagmus, may show considerable variation from day to day. There may be distinct tremor on the affected side in the 'finger–nose' test. The pointing test may be further elaborated by syringing the ear on the sound side with cold water, which will produce nystagmus, the slow movement of which is to the healthy side. As a result, the finger on the healthy side will past-point towards that side, but the pointing with the opposite hand (i.e., on the side corresponding to the diseased cerebellum) will deviate as before syringing. Complete hemiparesis of the limbs is occasionally met with, and is due to compression of the pyramidal tract below the decussation of the pyramids. Respiratory paralysis occurs not infrequently in cerebellar abscess, and is caused by 'corking' of the foramen magnum by the brain-stem. (The Trendelenburg position may be of value in the treatment of these cases, in addition, of course, to artificial respiration and the immediate evacuation of the abscess.)

COURSE AND TERMINATION.—If untreated, a brain abscess invariably ends fatally. The patient at first becomes stuporose, but can still be roused, though his response to external stimuli is very slow ; he may even fall asleep while attempting to eat. The stupor deepens to coma, which continues till death.

PROGNOSIS.—The prognosis of abscess of the brain is very grave. The statistics of various authorities differ, but it may be said that only from 20 to 50 per cent of cases are saved. Even after the apparently success- ful evacuation of an abscess, death may occur from a spreading septic œdema of the brain. Those cases are least hopeful in which more than one abscess is present, or which are complicated by meningitis or sinus thrombosis.

TREATMENT.—The treatment of brain abscess is operative. The first step is the performance of the mastoid operation. In acute cases it may suffice to perform the classical operation. If temporal lobe abscess is suspected, the tegmen antri is removed and a large area of the dura mater is exposed. A small incision is made and the brain explored medially, then forwards, and lastly backwards, with Cushing's pus- seeker. Ruttin and Beck agree that in exploring for a temporal lobe abscess it is safe to introduce the instrument for a distance of one and a half inches but not further. The instrument should in the first place be kept close to the floor of the middle cranial fossa. Lemaitre does not at once open the abscess, but uses a very small needle to explore the brain and, on reaching the abscess, waits until a drop of pus appears at the proximal end of the needle. He than enlarges the puncture with a small grooved probe and introduces the smallest rubber drain. Adhesions form round the tube, and two days later he enlarges the small hole by cutting into the fibrous tissue which has formed. This permits the introduction of a larger tube. The method has two advantages in that it obviates hernia of the brain and also meningitis. Drainage generally continues for four or five weeks. Since this method has been employed in the Royal Infirmary, Edinburgh, the results of treatment have considerably improved. Other surgeons drain the abscess by the insertion of a piece of iodoform gauze, or by one or two rubber tubes placed alongside each other, or by a 'cigarette' drain made of rubber-dam rolled round several strands of iodoform worsted. Some surgeons employ a small conical silver-wire basket lightly filled with gauze. A rise of temperature or a change for the worse in the mental condition calls for immediate exploration of the abscess and a search for obstruction to drainage or the development of additional foci of suppuration. Neumann gives a recovery rate of 34 per cent in abscess of the temporal lobe.

In the treatment of temporal lobe abscess, Eagleton recommends an osteoplastic flap above and clear of the affected ear ; the flap is reflected upwards, and the corresponding dural flap downwards.

In the case of cerebellar abscess, the sigmoid sinus is first of all exposed and the dura mater lining the posterior fossa separated with a blunt instru- ment from the bone of Trautmann's triangular area, medial to the sinus, as in Neumann's labyrinth operation (see p. 366, Figs. 205–208). This is the

usual route of infection, and affords the best chance of striking the abscess cavity, which is commonly in the anterior part of the lateral lobe. The dura mater is then incised, and the abscess opened with Cushing's pus-seeker or angled forceps, and drained. During the operation, and even beforehand, the patient's breathing may suddenly cease from 'corking' of the brain stem and pressure on the vital centres. Artificial respiration should at once be carried out, the head of the table lowered to lessen the 'corking' of the brain stem, and the posterior fossa quickly opened in order to evacuate the pus. When this has been done, spontaneous respiration re-starts at once. If, owing to the forward position of the sinus, it is difficult or impossible to evacuate the abscess by the 'internal' route, it is necessary to expose and open the dura mater behind and below the sinus in order to obtain drainage. (In some cases both routes may be used for draining the large abscess.) Neumann gives a recovery rate of only 12 per cent in cases of cerebellar abscess : other surgeons, however, record a higher percentage of cures. The rubber tubes or cigarette drains should not be removed too soon, especially in cases associated with chronic purulent otitis media. If, after the abscess has been drained for a week or so, the daily removal of the tube or gauze packing appears to show that the abscess cavity is dry, the surgeon may be tempted to omit drainage altogether. Such procedure is often followed by a recrudescence of the symptoms, e.g., headache, drowsiness, slow pulse, etc., and on opening up the abscess again an accumulation of pus is evacuated. Such apparent 'recurrences' of the abscess may take place on two or more occasions when drainage is omitted. The safest plan is to diminish gradually the amount of gauze packing, or to shorten the drainage tube, or put in a smaller one, till a cure is effected. The patient should be kept under observation for a considerable period after he has apparently recovered, as 'relapses' have taken place after an interval of six months or more. Convulsions have occasionally been noted after the healing of the temporal lobe abscess, or the patient's disposition may be altered for the worse. Some surgeons advocate complete removal of chronic abscesses which have thick capsules and can be 'shelled out' after a large area of brain has been exposed.

Hernia of the temporal lobe or of the cerebellum may follow operation especially in cases in which a large incision has been made in the dura mater. No attempt should be made to excise the hernia as this only results in spreading the septic encephalitis from which the hernia arises. The hernia should be covered with gauze soaked in 5 to 10 per cent formalin solution and covered by rubber tissue. This results in an aseptic slough which is gradually removed. Repeated lumbar puncture may also be employed.

VENOUS INFECTIONS.

SINUS THROMBOSIS.

The transverse sinus is the venous channel most frequently affected by purulent inflammation, and from it the disease may spread (a) backwards to the confluens sinuum (torcular) ; (b) rarely forwards

to the superior petrosal and cavernous sinuses; or (c) downwards to the bulb and the internal jugular vein in the neck. As the superior longitudinal sinus sometimes opens into the right transverse sinus it is evident that in such cases the right sinus will be larger than the left. Drowsiness and vomiting are sometimes observed after operation on the right transverse sinus and are due to interference with the venous return from the brain.

Thrombophlebitis of a venous sinus is one of the most common of otitic intracranial complications; it occurs in both acute and chronic suppurations, though more frequently in the latter, because cases of
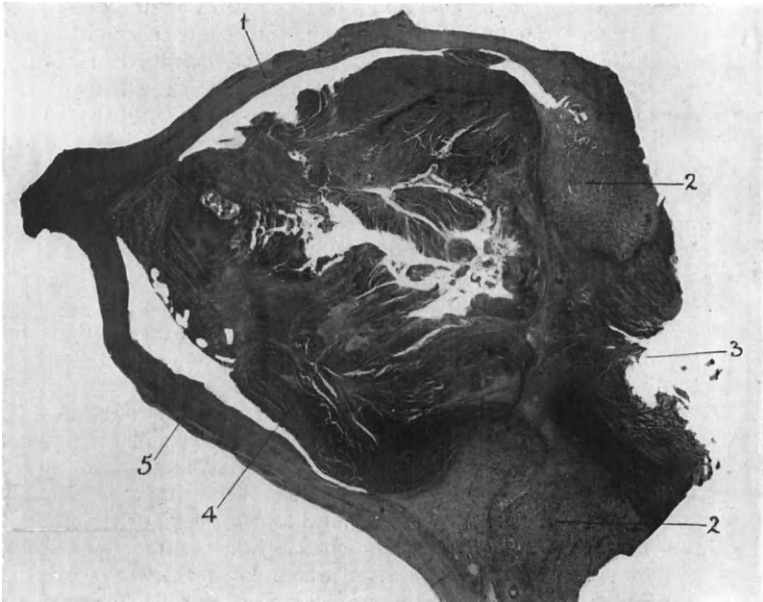
Fig. 213.—Horizontal section through thrombosed sigmoid sinus, showing extradural perisinus abscess. (1) Normal dura of sinus wall; (2) Sinus wall replaced by granulation tissue; (3) Position of perisinus abscess; (4) Laminated clot in sigmoid sinus, breaking down in the centre; (5) Normal dura of cerebellar surface of the sigmoid sinus.

chronic suppuration are more numerous than acute cases. Thrombosis is a protective effort on the part of Nature. The organism present is usually a streptococcus.

The infection usually passes through the bone to the walls of the sinus where an extradural perisinus abscess may be formed. Such an extradural abscess may be present for a considerable period before the wall of the sinus succumbs and a clot is formed on the adjacent wall of the vessel. If the process continues, the thrombus spreads upwards and backwards as far as the entrance of the superior petrosal sinus, and forwards and downwards to the jugular bulb. At these points the thrombosis tends to stop; but if it extends backwards beyond the

opening of the superior petrosal, there is nothing to prevent its reaching the confluens sinuum (torcular). In the same way the thrombus, after passing the jugular bulb, continues until the junction of the common facial and the internal jugular veins is reached, where again there is a natural tendency to arrest of the process (Jones). Long before this stage has been reached, the transverse (sigmoid) sinus in the region of the upper 'knee' has become occluded. An abscess forms from the breaking

Fig. 214.—Vertical coronal section through middle and inner ear showing route of infection in a case of primary septic thrombosis of the jugular bulb. (1) Smooth part of superior vertical canal ; (2) Ampulla of superior canal ; (3) External meatus ; (4) Tympanic cavity ; (5) Pus in lower part of tympanum ; (6) Thickened lining membrane of jugular bulb ; (7) Laminated clot in the bulb ; (8) Point at which infection passed from tympanum to bulb ; (9) Ampullary end of posterior vertical canal ; (10) Crus commune.

down of the clot, portions of which may pass into the blood-stream and set up abscesses in distant parts of the body (pyæmia). (*Fig.* 213.)

Atypical Cases.—Especially in cases where there is an almost complete absence of mastoid air-cells, and where in consequence the sigmoid sinus lies far forward, the infection may pass by way of the small veins which open into the sinus without the formation of an extradural perisinus abscess. In such conditions the thrombosis is of endophlebitic origin, and when exposed at operation the sinus wall may show little or no

change.   In rare cases the veins passing through the floor of the tympanum to the jugular bulb may carry infection and produce primary thrombosis of the bulb (*Fig.* 214).   Pyæmic symptoms come on more rapidly in these cases.

SYMPTOMS.--Sinus thrombosis may run its course without symptoms ; but in most cases it is characterized by the occurrence of chilly sensations or rigors, in which the temperature rises suddenly to 103° or 104° F., and falls again as rapidly, the fall being accompanied by profuse sweating (*see Fig.* 209).   (As the rise of temperature usually occurs in the after noon or evening, the practitioner should visit the patient at these times. If the temperature is taken only in the morning, its characteristic hectic character will be overlooked.)   There may be only a single rigor (as a rule in the afternoon or evening), or several may occur in a day. A high evening temperature for several days after a mastoid operation calls for prompt exposure of the trans-

Fig. 215.—Cavernous sinus thrombosis.

verse sinus.   The pulse rises with the temperature.   In the intervals between the rigors, the patient may be free from symptoms; but in some cases, especially later in the disease, the temperature remains elevated.   Headache and vomiting are sometimes met with ; the tongue presents a very significant appearance and is usually dry and brown ; there may be herpes or sordes on the lips ; the spleen may be enlarged ; choked optic disc occurs in a considerable proportion (two-thirds) of cases.   (Lumbar puncture has proved of advantage in this condition.)   Occasionally œdema is manifest in the neighbourhood of the mastoid emissary vein (Griesinger's sign).   When the thrombosis extends into the neck, torticollis may supervene, and tenderness may be complained of along the line of the jugular vein, while a swelling, due to inflammatory enlargement of the cervical lymphatic glands, is sometimes found.   If the thrombosis extends along the superior or inferior petrosal sinuses to the cavernous sinus, protrusion and immobility of the eyeball results, with ptosis, dilated and fixed pupil, marked swelling of the eyelids and conjunctiva, rapid deterioration of vision, engorgement of the retinal vessels and retinal hæmorrhages.   Extension to the opposite cavernous sinus via the circular sinus takes place in about 50 per cent of cases (*Fig.* 215).   There is severe pain around the affected eye or eyes, and signs of meningeal irritation are usually present and may be followed by meningitis.

As a result of the escape of portions of the clot into the general circulation, septic pneumonia and empyema (infarction) may arise, or metastatic abscesses may appear in other parts of the body, especially in the subcutaneous tissues or in the bones and joints.   If the septic particles are large they are held up in the pulmonary capillaries, but if

they are small they can pass through and reach the bones, joints or subcutaneous tissues.

A sinus thrombosis, if untreated, ends fatally as a rule ; but cases of the spontaneous cure of this condition are on record, the sinus being converted into a cord of fibrous tissue. In other rare cases the distal ends of the clot remain firm and become organized, while the centre breaks down and drains into the mastoid process through a spontaneous rupture of the anterior sinus wall. Septic thrombosis may end fatally in a few days, but sometimes it is very slow, and death may not occur until after an interval of several weeks.

DIAGNOSIS.—The conditions with which sinus thrombosis is most likely to be confused are malaria, typhoid fever, bronchopneumonia and erysipelas. A careful history of the case, together with an examination of the blood and the administration of quinine, should exclude the former. The presence of a positive Widal reaction, with petechiæ in the skin and the absence of rigors and marked variations in temperature, are sufficiently distinctive. In bronchopneumonia there is persistent cough with expectoration. In regard to erysipelas it is important to remember that this condition may be present without marked redness of the skin. The presence of nystagmus to the affected side strongly suggests erysipelas. The diagnosis of sinus thrombosis is suggested by the occurrence of rigors in the course of a middle ear suppuration ; it is more difficult if the condition is complicated
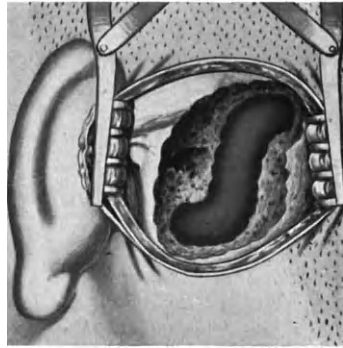
Fig. 216.—Exposure of sigmoid sinus.

by the presence of meningitis or brain abscess. Sinus thrombosis may occur in cases where middle ear suppuration is not suspected ; this error is not likely to arise if the condition of the ears is inquired into. A high leucocyte count indicates a strong reaction, while a small count indicates a weak reaction. A high percentage of polymorphonuclear leucocytes (80 to 95 per cent) shows a severe infection. Repeated examinations of the blood are of more value than single tests in regard to prognosis, but it cannot be said that the leucocyte count serves to distinguish cases of venous infection from those of extradural abscess or septic meningitis. As a rule, however, the count is lower in brain abscess than in the other intracranial complications (Darling). Blood-cultures have been employed as an aid to diagnosis, but have not been found of great value, because (1) living organisms are not always present in the peripheral veins even in cases of undoubted sinus thrombosis (blood-cultures should be made when the temperature is rising, commonly in the early part of the afternoon), and (2) the organisms may not show a growth until forty-eight hours have elapsed, when in the majority of cases immediate operative interference is called for.

25

The general aspect of the patient differs markedly in the three main intracranial complications—purulent leptomeningitis, brain abscess and septic sinus thrombosis. In leptomeningitis the patient is anxious, frightened, and has a very severe headache. In brain abscess he is usually dull and apathetic, though here also the headache is sometimes severe. In septic sinus thrombosis the patient is bright and, when questioned, usually says he feels well, except, of course, during or just after a rigor.

PROGNOSIS.—The prognosis of transverse sinus thrombosis is more favourable than that of brain abscess, if an operation is performed before systemic infection has occurred and if there is no other intracranial complication. The recovery-rate is from 50 to 70 per cent.

TREATMENT.—The treatment consists in removing the primary focus of disease, by performing the classical operation in cases due to acute middle ear suppuration, and the radical operation in cases of chronic otorrhœa. If sinus thrombosis be present, there is usually excessive bleeding from the bone at the mastoid operation. In every case which shows symptoms suggestive of extradural perisinus abscess or sinus thrombosis, the sigmoid sinus should be exposed (*Plate XX*, F, p. 342, and *Fig.* 216) until healthy wall is seen.

1. If an extradural perisinus abscess is found, with healthy red granulations on the sinus wall, and if only one rigor has occurred, it is advisable to leave the wound open and await developments. The presence or absence of pulsation of the sinus wall is not an absolutely reliable guide to the condition of the contents, though the presence of pulsation is strongly in favour of thrombosis. Much can be learned by palpating the sinus with the index finger, and if this is practised on the normal sinus, an abnormal condition can be fairly readily detected. If on compressing the exposed sinus wall with a blunt probe and suddenly releasing the pressure the wall returns to normal evenly and instantly, the sinus should not be opened, though the case should be watched for further developments (Muecke). Exploration of the sinus by means of a needle and syringe may be fallacious but is much more reliable than inspection.

2. If the temperature rises over 100° F. for two successive nights, or if the sinus wall at the first operation appears greyish-yellow or brownish-green and sloughy, it is certain that a septic sinus thrombosis is present. After the sinus has been exposed until healthy bluish wall has been reached in the direction of the torcular, an attempt may be made to shut off the flow of blood by means of gauze packing introduced between the wall of the vessel and its overlying bone. The sinus must now be slit up with a knife and the clot removed. If a sharp-pointed knife is used great care must be taken not to go too deep and damage the inner wall of the sinus with consequent hernia of the brain tissue. In most cases it will be found that profuse hæmorrhage occurs in spite of our attempt (described above) to stop the flow from the torcular. It will therefore be necessary to introduce iodoform worsted into the lumen of the transverse sinus itself in order to check the hæmorrhage (*Fig.* 217). It is more difficult to get below the clot in the direction of the jugular

bulb, and most authorities make a routine practice of exposing and dividing the jugular vein in the neck, at the point of entrance of the common facial, with a view to preventing systemic infection. The facial vein is also divided between ligatures. It is not uncommon in children to find the tonsillar gland enlarged and surrounded by adhesions, as it lies between the common facial and internal jugular veins, thus making the ligations more difficult. In any case the internal jugular should be ligatured and divided when it is found impossible to clear out the whole of the clot from above. Very little if any permanent disfigurement is caused by allowing the wound in the neck to granulate
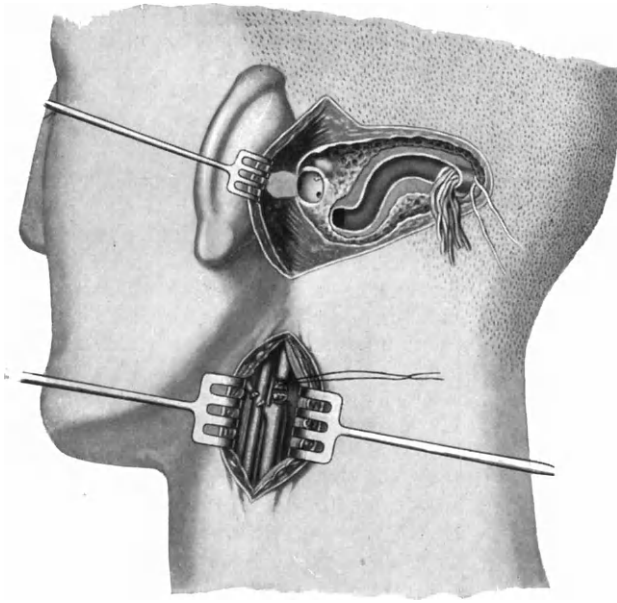
Fig. 217.—Operation for septic thrombosis of sigmoid sinus. The radical mastoid operation has been performed in this case and the sinus exposed well behind the upper knee. The torcular end has been plugged with iodoform worsted and the lateral or anterior wall of the sinus has been cut away with scissors. The internal jugular vein has been divided between ligatures after the common facial vein has been tied off.

and close itself without the aid of secondary sutures. As a rule the upper or bulb end of the internal jugular vein should not be opened at the time of operation as this procedure is followed by excessive hæmorrhage. It is better to wait for two or three days till clotting occurs. If the vein is not opened then it becomes a bag of pus and the patient suffers from septic absorption.

Even after the sinus has been successfully dealt with and the jugular vein ligatured, it is by no means unusual for the hectic temperature to recur after an interval of a day or two. Such recurrence by no means precludes a successful termination of the case. If, however, rigors continue and the patient is rapidly losing ground, it is advisable to

expose and drain the jugular bulb by following up the sigmoid sinus from the lower knee, care being taken to avoid the descending portion of the facial nerve, which lies close to the lateral aspect of the bulb. A more extensive operation which lays open the whole venous channel from the sigmoid sinus, through the bulb to the jugular vein, has been devised by Tandler.

When there is undoubted evidence of pyæmia, such as metastasis, the operation on the jugular vein should precede that on the sigmoid sinus. In the after-treatment, syringing may be carried out from the bulb to the vein.

Septic thrombosis of the sinus occasionally follows accidental injury to the vessel wall during the course of a mastoid operation. Symptoms of thrombosis may occur from seven to ten days after the injury (Hunter Tod). In cases in which the sinus wall has been actually injured at a mastoid operation, a 'postage stamp' graft of fascia from the mastoid cortex, or a piece of temporal muscle, should be cut off and applied ; the wound should be packed and left unstitched. If symptoms of venous infection, such as an elevated evening temperature or sudden rigor, arise, the case must be dealt with as indicated under sinus thrombosis.

AFTER-TREATMENT must be energetic. In order to neutralize the poisons in the patient's system anti-toxin is employed. Streptococcus antitoxin (Scarlatinal) (when the infecting organism is a streptococcus) is given intravenously in 30 c.c. doses daily, up to a maximum of 120 c.c. Should the organism be a pneumococcus it must be typed, and if belonging to Groups I or II, the corresponding serum should be administered as above. The patient has probably lost a fair amount of blood at the operation, and as a toxic anæmia is a marked feature of this disease, a blood transfusion should also be employed.

If at all possible the patient should be nursed in an outside balcony, the fluid intake should be increased and vitamin treatment instituted. Many drugs have been used for intravenous medication, but all have been found to be equally useless and in fact dangerous.

<center>OTITIC BACTERÆMIA OR SEPTICÆMIA.</center>

Many authorities doubt the possibility of otitic blood infection without the presence of septic thrombosis in a venous sinus or in the bulb of the internal jugular vein. Such a position is very difficult to assail, because it is known that septic thrombosis may recover spontaneously. Cases, however, have occurred in which the temperature chart pointed to otitic venous infection, and in which blood cultures made during the period of high fever were positive, though the sigmoid sinus, when opened, showed no evidence of clotting ; further, exposure of the upper part of the internal jugular vein revealed normal conditions. In the majority of these cases of aural bacterin the patients are young—usually children—and the otitis media is acute or subacute (Lake). The afternoon temperature varies from 100° to 105° F., but there is an absence of rigors and sweating such as occur in otitic pyæmia. The patient's mind is very active and the appetite is good. According to

Jenkins the leucocyte count is often a low one—6000 per c.mm., with a high polymorphonuclear percentage, thus showing poor resistance on the part of the patient. Mueller states that the occurrence of an eruption like chicken-pox in a case of otitis media should suggest the presence of bacteræmia.

PROGNOSIS in cases of aural bacteræmia is not unfavourable.

TREATMENT.—The primary disease in the mastoid must be thoroughly dealt with by the Schwartze operation. Jenkins finds the mastoid air-cells frequently lined by pale mucosa with 'laking' of the pus. (After operation there is little or no evidence of reaction in the wound.) At the time of operation the sigmoid sinus must be freely exposed. If the wall of the vessel appears perfectly normal, it is very doubtful if any good purpose is served by opening the sinus, though this course is advocated by McKenzie. The temperature falls after the operation, but unfortunately the fall is not permanent. The difficulty now arises that the case may be one of primary thrombosis of the jugular bulb due to infection passing through the floor of the tympanum. According to Milligan, if one sinus is occluded by thrombosis the normal venous 'hum' over the jugular vein on that side disappears, while it is audible on the healthy side. Crowe states that if in a normal person one internal jugular vein is compressed with the finger, no appreciable evidence of stasis is to be seen in the supra-orbital or retinal veins. If, however, both internal jugulars are compressed at the same time, a marked dilatation ensues. If the pressure is now released on one side while it is maintained on the other, the engorged veins empty immediately. If, however, the jugular bulb is thrombosed on one side—say the right—the veins will still remain engorged if the pressure is maintained on the left internal jugular, even though it is released on the right side. Queckenstedt's test consists in measuring the pressure of the cerebrospinal fluid by means of a manometer attached to a lumbar puncture needle. If, when the jugular vein on the affected side is compressed, there is little or no elevation of pressure, and if when the opposite jugular is compressed there is a marked increase, one is justified in diagnosing thrombosis.

As the diagnosis of aural bacteræmia is often a matter of doubt, it is advisable, if the treatment mentioned above fails to bring down the hectic temperature within a week, to deal with the transverse sinus and internal jugular vein as in cases of septic thrombosis. Primary thrombosis of the jugular bulb may occur especially in young children and is due to infection passing through the small veins from the floor of the tympanum. Such cases are very liable to be mistaken for aural bacteræmia.

MULTIPLE INTRACRANIAL COMPLICATIONS.

If only one intracranial complication is present in a given case of middle ear suppuration, the diagnosis and treatment are as a rule comparatively simple. Unfortunately, however, it not infrequently happens that more than one of the intracranial structures are involved. The following case illustrates this condition so clearly that it is worthy of quotation.

M. S., female, age 13 years, admitted Jan. 14, 1915, with foul-smelling dis-
charge from the right ear since measles some years before. On Jan. 8 she had
complained of earache, followed by vomiting and retraction of the head.

On examination, there was tenderness over the right tympanic antrum, and
otoscopy revealed sagging of the posterior superior meatal wall. The patient
was too ill for detailed functional examination, but was not quite deaf when
the noise apparatus was applied to the left ear. Tuning-fork on vertex lateral-
ized to the affected ear; no spontaneous nystagmus; temperature 100·6° F;
pulse 100. The patient cried out frequently (meningitic cry). There was
retraction of the head ; Kernig's sign +. The tongue was dry and furred.
On lumbar puncture, the cerebrospinal fluid was under great tension and
turbid. The fluid was acid and contained a great excess of albumin. Films
showed pus-cells and many Gram-positive cocci (short-chained streptococci).

An immediate radical mastoid operation was performed on the right ear.
The first gouge-cut opened a large extradural abscess around the sigmoid sinus,
containing foul-smelling, brownish-green pus. The tympanic antrum showed
cholesteatoma, and the tympanic cavity was full of granulations. As the wall
of the sinus looked brownish and sloughy, a second incision was made in a
horizontal direction backwards and the sinus further exposed until healthy
wall was reached. The sinus was opened and a copious gush of blood escaped.
Iodoform worsted was therefore packed into the sinus, and the operation
cavity lightly plugged. On Jan. 15 the child was again crying out. A second
lumbar puncture revealed cloudy fluid but under less tension ; temperature
100° F. The child looked ill and there was marked herpes on the upper lip.
Kernig's sign present on both sides ; abdomen retracted. On Jan. 19 lumbar
puncture yielded clear fluid, which came out in drops (pure growth of strepto-
cocci obtained). On Jan. 20 the temperature rose to 104° F. in the afternoon ;
pulse 120. The symptoms of meningitis, however, were passing off. There
was no restlessness or irritability, and the patient did not complain of headache.
There was no paralysis of the eye muscles, no double vision, no photophobia,
and no pain on pressure on the eyeballs ; Kernig's and Babinski's signs absent.

On the other hand, the patient was now lying curled up on her left side.
The tongue was furred and the breath foul ; constipation present. The mental
condition was fairly good, and the girl answered questions at once. There was
some stiffness of the neck, and when she sat up she held her head with
her hands.   The head was moved stiffly from side to side or up and down.
There was tenderness over the right occipital region ; no vomiting. Although
the patient was right-handed, the grasp of the right hand was not so strong
as that of the left, and on trying the pronation and supination tests, the right
hand tired more easily than the left (dysdiadokokinesia). The spontaneous
pointing test was normal. There was slight spontaneous nystagmus to the
right (diseased side). With the noise apparatus in the left ear the patient
repeated the raised voice. Labyrinthitis was therefore excluded. The wound
did not show much reaction.

Jan. 20.—Rigor; temperature 103·6° F. *Second operation* : The sigmoid
sinus was slit up and found to be thrombosed. Free bleeding was again
obtained from the transverse sinus, behind entrance of superior petrosal. This
portion of sinus was again packed with iodoform worsted. On following
the sigmoid sinus towards the jugular bulb, free bleeding was not obtained.
Accordingly an incision was made in the neck along the anterior border of the
sternomastoid muscle. The common facial vein, with the lower part of the
internal jugular, contained fluid blood, but the upper part of the internal
jugular was thrombosed. The common facial was divided between ligatures,
and the internal jugular was also ligated in two places and divided. (Cultures
from the wall of the transverse sinus gave pure colonies of streptococcus, as did
also the clot from the jugular vein.)

Jan. 22.—Patient vomited twice during the night. Temperature 99·8° F. There
is nystagmus to the left (sound side). On looking to the right there are
large slow nystagmic movements—evidently the nystagmus is of the 'extra-
ordinary' type and is not due to labyrinth suppuration. On testing the
pointing reaction the right hand deviates to the right.

Jan. 25.—Temperature 102° F. Child is spitting up foul-smelling, brownish-red material; vomiting continues. There is headache with stiffness of neck, and pain in the right side of the chest. Patient can still hear with the right ear, and on syringing the operation cavity with cold lotion there is a marked increase in the spontaneous nystagmus to the left, thus showing that both functions of the right labyrinth are retained. In view of the presence of vomiting, headache, retraction of head, extraordinary nystagmus, and pointing error, it was determined to open the dura mater of the posterior fossa through the large area exposed in the operation on the sinus. *Third operation*: The right lateral lobe of the cerebellum was adherent to the dura mater, and did not bulge out when the incision was made. Cerebellum incised and a gush of foul yellowish-green pus obtained. Lumbar puncture—clear fluid under tension.

Jan. 28.—Temperature 102° F.; no vomiting or headache. Child takes food well, but suffers much from cough and expectoration. Dr. Edwin Bramwell finds signs of a cavity in the right lung.

Feb. 8.—The temperature swings from 100° in the morning to 102° F. at night. The neck wound has almost healed, but there is still pus from the region of the jugular bulb. The cerebellar abscess cavity is free from pus. Cerebrospinal fluid is turbid and under increased pressure. The fluid contains large numbers of cells, chiefly polymorphs, and, on culture, a bacillus of the colon group. The patient is sleeping and eating well, but is still spitting up a large quantity of foul yellow pus.

March 1.—Patient is feeble and emaciated; head retracted. Cerebellar abscess opened up and a considerable quantity of pus evacuated. Expectoration continues. Lumbar puncture—turbid fluid under increased tension.

March 19.—A cerebellar hernia has formed and pus is still present in the cerebellar abscess.

May 23.—The wound behind the ear is now healed. There is no headache or dizziness on pressure over the hernia cerebelli.

June 17.—The patient is quite unable to walk or even to stand. She at once falls over to the right (diseased side).

Sept. 10.—Patient, who has been at home for two months, reports to-day looking fat and well; she has gained enormously in weight. There is still slight bulging of the hernia cerebelli. The girl can walk well and has no difficulty in balancing.

1927. Patient now married and has a family.

REMARKS.—When the patient was admitted the symptoms and signs of purulent leptomeningitis predominated, and lumbar puncture confirmed the diagnosis. Within a week of the first operation, the symptoms of leptomeningitis had almost entirely passed off and the cerebrospinal fluid had become clear, but signs suggestive of cerebellar abscess now became prominent. There were, in addition, symptoms of an otitic venous infection—an evening rise of temperature to 104° F. Suddenly there was a marked rigor. The second operation showed that the lower part of the sigmoid sinus, jugular bulb, and upper part of the internal jugular vein were thrombosed. The thrombosis had probably been present at the time of the first operation, but had been missed, as the sigmoid sinus had been opened at its junction with the transverse sinus instead of below the upper knee. Immediately after the venous infection had been dealt with the signs of a right-sided cerebellar abscess again asserted themselves—extraordinary nystagmus, dysdiadokokinesia, pointing error, vomiting, etc. At this period symptoms of gangrene of the lung supervened, evidently the result of septic infarction. After the cerebellar abscess had been evacuated the patient made a slow recovery.

CHAPTER XXXIX.

CHRONIC CATARRH OF THE MIDDLE EAR.
CHRONIC ADHESIVE PROCESS.
OTOSCLEROSIS. OTALGIA.

CHRONIC CATARRH OF THE MIDDLE EAR.

ALTHOUGH chronic catarrh of the middle ear does not occupy so prominent a position in modern as in old text-books on otology, the condition is sometimes met with, especially in cases of adenoids and nasal and pharyngeal catarrh. On microscopic examination Habermann found the normal longitudinal folds of the Eustachian tube exaggerated, the lumen of the tube and tympanic cavity filled with glairy mucus, and the drumhead retracted. Habermann asserts that the proliferative changes in the mucosa exactly correspond to those found in chronic nasal catarrh. In the later stages the tympanic cavity may be almost obliterated by adhesions and the movements of the ossicles markedly impeded.

Deafness is the most marked and usually the only symptom. If severe tinnitus is present, secondary otosclerosis should be suspected.

On otoscopic examination the drumhead is indrawn, opaque and lustreless. Sometimes the membrane is congested and shows desquamation of the outer epithelial layer. Careful examination of the nose and nasopharynx is called for.

TREATMENT should be mainly directed to the associated nasal and pharyngeal affections. Inflation of the middle ear by Politzer's method or by the Eustachian catheter is also called for (*see* p. 305). If the Eustachian tube is impermeable, fine silver or celluloid bougies may be passed up the Eustachian catheter and through the tube (*see* p. 309). Dan McKenzie recommends the following solution for inflation, through a wide Eustachian catheter, at least once a week :—

R   Iodin. Resublimat.   gr. ij–iv | Menthol   gr. iij–v
        Ol. Sassafras   ℳj | Paraffin. Liq.   ad ℥j

A few drops of this liquid should be slightly warmed and injected into the catheter with a Pravaz syringe, while the patient holds his head back. The liquid is then injected into the tube and tympanum by means of the Politzer bag. Dundas-Grant finds that by passing a small Weber-Liel catheter through the ordinary silver catheter he obtains a better inflation of air into the middle ear. Finally, vaccine therapy is sometimes useful in cases of chronic nasopharyngeal and middle ear catarrh.

During recent years there has developed a tendency to diagnose chronic middle ear catarrh less and less frequently, and to divide cases of deafness in which such a diagnosis was formerly arrived at into (1) those caused by past attacks of catarrh or suppuration in the middle ear cleft,

i.e., chronic adhesive process in the middle ear, or cicatrized tympanum, and (2) those due to otosclerosis.

CHRONIC ADHESIVE PROCESS.

Permanent stricture of the auditory (Eustachian) tube is a frequent result of repeated attacks of middle ear catarrh. The narrowest part of the tube is in the cartilaginous portion just before it joins the tubal part of the tympanic cavity, and it is here the stricture is usually situated. On otoscopic examination the tympanic membrane is seen to be indrawn, opaque and often lustreless. It may show areas of thickening usually described as 'chalk patches'. In cases of marked indrawing, the short process of the malleus is very prominent, and the handle occupies such a horizontal position that it is difficult to see it, especially as the posterior fold of the membrane stands out very clearly. In many cases the drumhead is adherent to the inner wall of the tympanum in whole or in part, and the niches of the oval and round windows are filled up by fibrous tissue. Functional examination gives the results indicating obstructive deafness. On attempts at inflation with the aid of the catheter, the auscultation sound may be faint and distant and it may be accompanied by râles. It is, however, usually absent. The act of swallowing may not aid the passage of air along the tube. Even if a little air does enter, the drumhead is not blown out, owing to the tympanic adhesions and the permanent shortening of the tendon of the tensor tympani.

DIAGNOSIS.—This is easily made from the appearances of the tympanic membrane, but in some cases it is difficult to be certain that otosclerosis is not present in addition to the adhesive process. If there are other cases of otosclerosis in the patient's family, the diagnosis is more likely. It is important that school children should have their hearing tested at intervals by the audiometer, as any deafness can be detected and treatment instituted at a time when the best results can be expected.

PROGNOSIS.—This is unsatisfactory in advanced cases at any rate.

TREATMENT.—As advanced cases are almost incurable, our aim should be to prevent the onset of the trouble or to treat it energetically in its early stages. Adenoids and other causes of nasal obstruction should be dealt with. Exudate in the middle ear should be dispersed by inflation or expelled by paracentesis, followed by politzerization (*see* p. 305). Even in well-established cases the effect of politzerization should be tried ; if improvement results, the inflation may be repeated every second day for a month or six weeks, after which it should be discontinued for a similar or longer period. If it is impossible to inflate the ear by Politzer's method, the catheter must be used, and if this fails, attempts may be made to dilate the Eustachian tube by means of a fine gum-elastic or celluloid bougie which is passed up the Eustachian catheter. The application on a dressed probe of 5 per cent cocaine with adrenalin to the Eustachian tube facilitates the passage of the bougie. The probe may be passed up the Eustachian catheter, or may be passed along (say) the right inferior nasal meatus, and introduced into the right tube under the guidance of the nasopharyngoscope, which is passed through the left nostril. After the tube has been dilated, a 1 per cent

solution of nitrate of silver may be applied on a fine dressed probe, or medicated bougies may be employed. Some otologists, in order to dilate the stricture, have employed electrolysis with the aid of gold bougies, but it cannot be said that this line of treatment has been extensively adopted. Other authorities advocate the injection of medicaments through the Eustachian catheter, but it is questionable if much benefit is to be gained by their use. If resistance is met with, the bougie should be pushed forward with the greatest caution and, when the constriction has been passed, the instrument should be left in position for five or ten minutes in order to effect dilation. On removing the bougie, inflation is again carried out and, in successful cases, the air is heard to enter the tympanum more freely than before. The hearing distance for the human voice should be tested before and after inflation and, if there is marked improvement, the procedure may be repeated two or three times a week for several weeks. In the majority of cases, however, no improvement follows the passage of the bougie and inflation. In these circumstances the procedure should be abandoned.

Operative treatment, at one time freely resorted to in these cases, has now fortunately been abandoned by nearly every aurist. The operations were : artificial perforation of the drumhead, division of the posterior fold, tenotomy of the tensor tympani, and mobilization of the ossicles.

OTOSCLEROSIS.

(Dry Middle-ear Catarrh ; Ostitis Vasculosa ; Hereditary Deafness ; Spongification of the Labyrinth Capsule.)

In normal conditions the membranous labyrinth is surrounded by two distinct layers of bone : (1) The inner of these two, the labyrinth capsule proper, is composed of dense bone directly derived from the cartilaginous capsule of the otic vesicle in the embryo. For good hearing it is necessary that the nerve structures of the inner ear should be immediately surrounded by this layer of dense non-vascular bone. (2) Enclosing the cartilage bone, but distinct from it, there is the ordinary lamellar bone derived from the mucoperiosteum of the middle ear and from the osteogenic layer of the dura mater. These two layers are partially separated from one another in the embryo, and also in infants, by a well-marked lymph space. In young subjects, remains of fœtal cartilage are sometimes to be found in the promontory near the anterior margin of the oval window (*Fig.* 218).
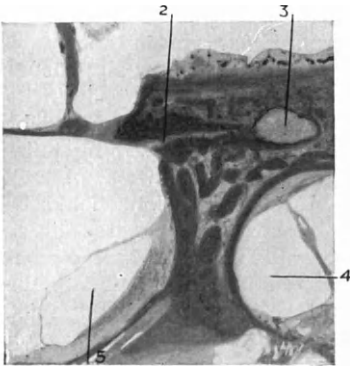
Fig. 218.—Horizontal section through anterior margin of oval window of fœtus. (1) Footplate of stapes ; (2) Fibrous tissue joining endosteum of vestibule to (3) Remains of fœtal cartilage in bony capsule of cochlea ; (4) Basal coil of cochlea ; (5) Saccule.

Otosclerosis is a very common disease. Gray holds that one person in every two hundred suffers from the affection. Shambaugh finds that one-third of his otological patients are suffering from otosclerosis.

ETIOLOGY.—The disease is much more common in the female than the male sex. There is a marked hereditary tendency to otosclerosis in certain families, and in nearly 50 per cent of cases a history of deafness in the family can be obtained. In families in which otosclerosis is present it is found that all the deaf members belong to the same blood group. This shows that otosclerosis tends to follow the laws of heredity. The disease usually becomes manifest between the ages of eighteen and thirty, but may begin earlier. Some hold that it is already present in embryonic life, though it only begins to manifest itself after puberty. Among the conditions which have
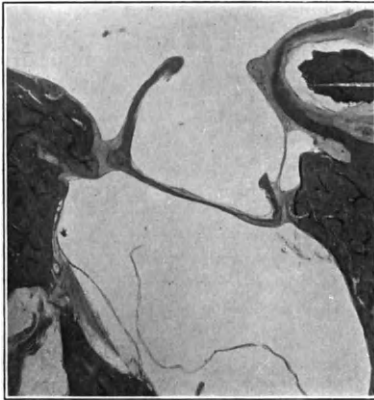
Fig. 219.—Normal joint between footplate of stapes and margin of oval window.

Fig. 220.—Otosclerosis following chronic purulent otitis media. The figure shows a horizontal section through the region of the oval window and basal coil of the cochlea. (1) Long process of incus, surrounded by connective tissue; (2) Malleus; (3) Area of ostitis vasculosa (otosclerosis) joining footplate of stapes to anterior margin of oval window; (4) Basal coil of cochlea; (5) Saccule; (6) Utricle; (7) Footplate of stapes; (8) Posterior margin of oval window—note that the footplate of the stapes is jammed against the posterior margin, but is not ankylosed; (9) Cystic spaces, which represent all that remains of the tympanic cavity, which is otherwise almost obliterated by the formation of very vascular granulation and connective tissue.

been stated to be possible causes are rheumatism, anæmia, intestinal auto-intoxication, and osteomalacia. Stein holds that there is a definite connection between sexual functions and disturbances and the onset of otosclerosis which occurs particularly at puberty, during pregnancy, and at the climacteric. In almost all cases the Wassermann reaction is negative. Abnormalities of the sympathetic nervous system and ductless glands, e.g., pituitary, parathyroid, ovary, and suprarenals, may have some connection with the condition. Some observers regard otosclerosis as due to a disturbance which involves the whole metabolism and assert that otosclerotics show characteristic biochemical changes.

PATHOLOGY.—The bony changes vary according to the duration of the

disease. At first the normal bone is absorbed and replaced by vascular spongy osteoid tissue. The process advances along the blood-vessels. Later the new bone becomes thicker and less vascular. The most common site of disease is the promontory in the region of the anterior margin of the oval window (*Figs.* 219, 220, 221), and in advanced cases the stapes becomes ankylosed in position by a mass of spongy new bone. Various reasons have been given to explain this 'site of election' for bone disease in otosclerosis. Thus the presence here of the tendon of the tensor tympani and of the facial nerve, and the greater movement of the anterior part of the stapedial footplate compared with the posterior part, have been regarded as predisposing the anterior margin of the fenestra vestibuli to spongification. It appears more than probable, however, that the explanation lies in the fact that there is in this region an anastomosis between the vessels of the middle ear and those of the labyrinth capsule.

There are various theories as to the pathology of otosclerosis :—
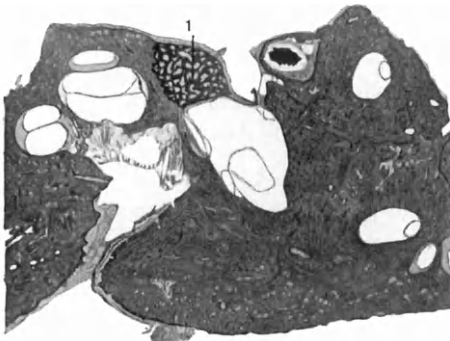
Fig. 221.—Otosclerosis, with ankylosis of footplate of stapes to anterior margin of oval window. (1) Spongy bone.

1. That it is a chronic, locally infective inflammatory process, starting in the muco-periosteum of the middle ear, i.e., that the affection is the result of otitis media—catarrhal or purulent. The walls of the tympanic cavity along with the ossicles and joints, are almost the only bones and joints in the body that are covered merely by mucous membrane. They appear therefore to be specially liable to infection from the surface. The factor of heredity, so marked in otosclerosis, may merely imply that in certain families the auditory apparatus is congenitally weak and unable to throw off completely an attack of acute otitis media. Wittmaack has produced congestion in the labyrinth of fowls by ligaturing veins. He claims that the consequent changes in the labyrinth capsule correspond to those seen in otosclerosis. Otto Mayer, however, does not agree, but finds evidence of spontaneous fractures of the labyrinth capsule in cases of otosclerosis.

2. Otosclerosis is regarded by some as an hereditary developmental anomaly in the post-embryonic growth of the labyrinth capsule. The primary fault is an inherent defect in the living cells of the organ of hearing (Gray). Variations are more apt to occur in structures such as the cochlea which are of comparatively recent origin than in those of more ancient descent, e.g., the vestibular apparatus. Otosclerosis is sometimes associated with congenital fragility of the bones and blue sclerotics. It is interesting to note that in all these conditions the affected structures are of mesenchymatous origin. Brunner holds that

otosclerosis is a dystrophic process due to a constitutional transmissible tissue weakness.

3. Others hold that otosclerosis is due to a blood infection, and is only a part of a general toxic condition. Jenkins points out the similarity of the changes in the bone in osteitis fibrosa and otosclerosis. The cochlear capsule is affected in some cases of the former disease, but the stapes does not become ankylosed. Other observers have called attention to the similarity of the changes seen in otosclerosis to those met with in rickets and osteomalacia.

4. Nerve involvement associated with anomalies of the endocrine glands may be at the root of the affection. Frey believes that otosclerosis is associated with hypofunction of the parathyroid glands.

5. Recently Gray has advanced the view that otosclerosis is due to faulty circulation in the labyrinth capsule and auditory nerve.

Eckert-Möbius holds that there are three factors in the evolution of otosclerosis : (1) A general constitutional factor, affecting the mesenchyma, due to inherited disturbances in the endocrine glands. (2) Between the terminal distribution of the primary cartilage vessels and the secondary bone vessels there is a biologically feeble osseous tissue in the position where otosclerotic foci are usually found. (3) An exciting factor : metabolic disturbances of general origin, especially seen in the female sex, or of local origin, e.g., otitis media.

SYMPTOMS.—The chief symptoms are gradually increasing deafness and tinnitus. The noises are often referred to the head and may cause the patient much more discomfort than the deafness. If tinnitus is marked, the case is likely to progress rapidly. Paracusis Willisii is frequently present, i.e., the patient states that he can hear better in a noisy place, such as a railway carriage or motor-car. Various explanations have been put forward to account for paracusis, the most probable being that patients suffering from otosclerosis and consequently unable to hear deep tones, obtain more advantage than normal people from the raising of their friend's voices in a noisy place, as they (otosclerotics) are not distracted by the low-pitched hum of machinery to the same extent as people with perfect hearing. Otosclerotics speak in a low, well-modulated voice, very different from the loud, harsh speech of an advanced case of nerve deafness. Giddiness is a rare symptom, but may be present if the foci of spongification reach the area cribrosa or region where the vestibular nerves pass through the bony capsule to reach the utricle and lateral and superior canals. Occasionally patients complain of slight pain in the ear.

EXAMINATION.—In otosclerosis the membrana tympani is often normal, and the external meatus wide and free from wax. In some cases a 'flamingo-red' shimmer can be seen through the membrane, due to the hyperæmia of the promontory, associated with ostitis vasculosa. The Eustachian tube is often patent. On the other hand, the presence of scars in, or opacity or retraction of, the drumhead, in association with Eustachian obstruction, by no means negatives the diagnosis as otosclerosis. Several cases have been recorded in which otosclerosis was combined with middle ear suppuration (*Fig.* 220).

Functional Examination.—Bezold's symptom-complex, or triad, has been found very reliable by most observers : (1) A raising of the lower tone-limit (the lowest tuning-forks, C 16, C 32, and in some cases C 64, are not heard by air conduction) ; (2) Increase of bone-conduction as tested with the meatus of the patient and of a normal person *not* occluded (C256 is well heard on the mastoid process by the patient after a normal person has ceased to hear it when in contact with his own) ; (3) Rinné's test is negative. The confident answer of the otosclerotic patient to the Rinné test is very characteristic. When the tuning-fork, which can no longer be heard by the meatal route, is placed on the mastoid, the otosclerotic patient says " Oh, yes " at once (Jenkins). In early cases the upper tone-limit is normal, while in late cases the upper limit is greatly reduced. The watch is well heard by bone-conduction in all but the most advanced cases.

Gellé's test for ankylosis of the stapes depends on the fact that if in a normal person the air-pressure in the external meatus is raised, the drumhead and ossicles are driven inwards and the labyrinthine pressure is raised. This causes a diminution in hearing in the ear under experiment. If, however, the stapes is ankylosed, no diminution of hearing is produced. The test is carried out as follows : An olivary nozzle attached by rubber tubing to a valveless Politzer bag is inserted tightly into the meatus. The butt end of a sounding tuning-fork (Vienna model) is placed on the bag and gradually pushed in so as to cause compression. A normal individual states that during the compression of the bag the sound of the fork diminishes but becomes louder again if the compression is released (Gellé positive). A patient with fixation of the stapes due to otosclerosis notices no difference (Gellé negative). Escat's test for ankylosis of the stapes is carried out by holding a vibrating tuning-fork of medium pitch opposite the ear to be tested, while the patient performs Valsalva's inflation. In normal persons the sound of the tuning-fork is diminished and the test is said to be positive. In stapes ankylosis there is no diminution of hearing and the test is negative.

DIAGNOSIS.—Diagnosis is made by attention to the following points : gradual onset of progressive deafness, usually with tinnitus ; history of hereditary deafness ; the patient hears better in a noise ; a red shimmer from the promontory may be seen through the drumhead ; the sensibility to tickling in the external meatus—as tested with a cotton-tipped probe—is considerably diminished, especially on the side of the deafer ear ; loss of the lower tones by air-conduction ; lengthened bone-conduction ; negative Rinné test. Senile nerve deafness only begins after fifty years of age, whereas otosclerosis comes on earlier. A correct diagnosis is of the greatest importance when we come to the treatment of the case. In many otosclerotics numerous operations have been performed on the inferior turbinals, nasal septum, fauces and nasopharynx, with the idea that the case was one of 'chronic catarrhal otitis media'.

Shambaugh points out that there are rare cases of otosclerosis in which the focus of spongification does not affect the region of the oval window but involves the capsule of the cochlea at a separate spot. In such cases there is no paracusis, and tuning-fork tests give the results

normally obtained in a case of nerve deafness. Shambaugh concludes that if a young or middle-aged patient suffers from nerve deafness for which no other cause can be found, and if in her or his family there are individuals suffering from typical otosclerosis, the case should be regarded as one of spongification of the labyrinth capsule (atypical otosclerosis).

PROGNOSIS.—Patients should be assured that the progress of the disease is usually very slow, that no brain disease is present, that the condition is not dangerous to life and does not result in absolute deafness. Pregnancy, illness, and accident may cause a rapid increase of the deafness and tinnitus. If the affection comes on early in life, the prognosis is extremely bad.

PROPHYLAXIS.—Female patients suffering from otosclerosis should be warned of the deleterious effects of pregnancy, and of the likelihood of handing on the 'otosclerotic tendency' to their children. Every effort should be made to obtain complete recovery in cases of acute otitis media, as this may be the starting point of otosclerosis.

TREATMENT.—Gray sounds a note of warning in regard to excessive consumption of meat, alcohol, tobacco, strong tea and coffee. Phosphorus has been strongly recommended, in pill form, $\frac{1}{60}$ gr., or as hypophosphites or glycerophosphates. Leicher recommends calcium chloride or bromide. Sodium iodide may be given in doses of 2 to 5 gr. for a period of thirty days, and then stopped for two months before the treatment is recommenced. Arsenic and iron should be tried in cases of anæmia. Extracts of the ductless glands—especially of the thyroid, parathyroid, pituitary and adrenal bodies—are supposed to have a beneficial influence on pathological processes in bone. Numerous cases have been treated with these remedies, but without any notable result.

It appears possible that otosclerosis may be delayed or even benefited by a series of autogenous vaccines made from secretion obtained from the nose and nasopharynx.

Local treatment is of very doubtful value. Formerly inflations of air or medicated vapours were frequently employed. Injections of fibrolysin, massage of the membrane and ossicles, mobilization or extraction of the stapes, local application of X rays, and radium have all proved useless. Dan McKenzie advocates the use of medical diathermy by means of two small electrodes wrapped in lint soaked in 10 per cent saline solution, one placed on the mastoid bone and the other on the opposite check. The séances last for half an hour and are repeated on six occasions. The current is raised slowly from zero and should only produce a comfortable sensation of warmth. Sir Robert Woods recommends injection of liquor iodi (B.P.) diluted to one-tenth strength : a special syringe is employed and the puncture made behind the malleus handle. There is some pain and reaction for a few days. Woods claims great improvement in hearing, at least in early cases. Gray states that the local application of thyroxine to the ear resulted in considerable improvement in hearing in seven cases (50 per cent) of his series.

For good hearing, two movable windows are required in the lateral wall of the labyrinth. Bárány and others have performed operations to make a window in the posterior or lateral canal to replace the oval

window which is ankylosed by the otosclerotic process. Sourdille has recently advocated a two-stage operation. The first stage consists in antro-atticotomy (p. 359) followed by removal of the incus and the formation of a plastic flap from the membranous meatus to shut off the lower part of the tympanum. Four months later the posterior wound is re-opened under local anæsthesia and the prominence of the lateral canal is scooped away with an eraseur until the membranous canal is exposed and a little perilymph escapes. The patient at once hears very well. The opening in the canal is covered by an epidermic flap to prevent infection of the inner ear. Patients in whom the operation is successful have thereafter a positive fistula symptom.

As regards the tinnitus, the patient should be advised to neglect the noises as far as possible ; these are always worst when the patient is alone and unoccupied. Bromides and iodides are occasionally helpful. Corrosive sublimate, $\frac{1}{60}$ gr. in pill form, may be given twice daily after meals for a month. Galvanism has been employed—the positive pole applied to the ear, and the negative pole to the back of the neck ; the current is begun at zero and increased up to 3 ma., and again diminished to zero ; the séance lasts for three minutes. The application of a blister over the mastoid process, in front of the tragus or below the lobule, may help the patient—at any rate for a time. Lumbar puncture has failed, as a rule, to alleviate the symptoms. The operative destruction of the cochlea, or division of the eighth nerve, may be justifiable (*See also* MÉNIÈRE'S SYMPTOM COMPLEX, p. 419).

The patient should be encouraged to *learn lip-reading as early as possible*, and warned against submitting to useless operations on the nose, throat or ear. Artificial aids to hearing are unnecessary in the early stages, but later on are sometimes of benefit (*see* p. 434). Patients with otosclerosis should avoid noisy surroundings, great bodily or mental fatigue and exposure to cold. So-called 'auditory re-education' requires elaborate electrical apparatus. Cathcart recommends treatment by this method, but reports by some other observers have not been favourable.

OTALGIA.

Earache is sometimes complained of when the ear is healthy ; in such cases a careful inspection should be made of the teeth, the nose, the pharynx and the larynx. Dental otalgia generally originates in disease of the lower molars, e.g., chronic pulpitis, gangrene of the pulp, or carious stumps. The pain is deep-seated and boring. It is generally intermittent and radiates from the external meatus. An unerupted wisdom tooth may cause intense pain in the ear. If the teeth are not diseased, the pharynx and larynx must be examined, for ulcerative processes in either of these regions may cause earache, which indeed is quite an early symptom of postcricoid carcinoma. The possibility of malignant or syphilitic ulceration of the nasopharynx must not be forgotten. Patients often complain of otalgia after the removal of tonsils while the throat is healing. Affections of the sphenoidal sinus may give rise to pain which the patient locates in the ear. It is obviously

necessary in such cases to treat the cause, as local treatment of the ear is unavailing. Neuralgia may also be caused by cold, neurasthenia and sexual disturbances. A persistent pain is occasionally experienced over the mastoid process after operations on neurotic subjects ; it may be due to the pressure of a firm cicatrix, but further operative procedures seldom result in permanent relief.

THE RELATION BETWEEN DISEASES OF THE NOSE AND THROAT AND OF THE EAR.

It has been shown that various morbid conditions in the nasopharynx predispose to ear affections, and that both have to be treated ; this is especially true of cases of Eustachian obstruction and of catarrhal or suppurative otitis media associated with hypertrophic nasal catarrh, deviations of the septum nasi, adenoid post-nasal growths and paranasal air sinus disease. If the hearing distance is markedly improved after inflation, operations on the nose and pharynx may be expected to ameliorate the ear trouble. It is, however, necessary to utter a warning against exaggerating the effect of intranasal disease in predisposing to affections of the ear. It is a common experience to find a nose full of polypi, or a marked deviation of the septum, without any impairment of the hearing. Again, in many cases of choanal atresia in which *a priori* an aural complication might be expected, there is no evidence that the ears are in any way affected. We may go so far as to say that to operate on minor intranasal abnormalities in order to improve the hearing is rarely justifiable, while operations undertaken for this purpose in otosclerosis are directly harmful.

CHAPTER XL.

TUBERCULOUS, SYPHILITIC AND MALIGNANT DISEASE OF THE EAR.

TUBERCULOSIS OF THE EAR.

External Ear.—Tuberculosis of the lobule is occasionally met with in women—the infection being due to the piercing of the lobule for ear-rings. The external ear may be involved by lupus. The most favourable form of treatment is removal of the affected part by the diathermy knife.

Middle Ear.—Cases of tuberculous otitis media may be divided into two groups :—

1. In infants and very young children who are fed, in whole or in part, on unsterilized cow's milk which contains the bovine type of tubercle bacillus. Logan Turner finds that, in otitis media at all ages, tuberculosis accounts for only 2·8 per cent of the cases ; under two years for 27 per cent ; under one year for 50 per cent. Suppurative otitis media in an infant should always make one think of tuberculous middle ear disease.

2. In the advanced stages of phthisis pulmonalis tuberculous disease of the middle ear cleft sometimes occurs. Ormerod has found that only 1 per cent of phthisical patients at Brompton Hospital suffer from tuberculous otitis media.

PATHOLOGY.—*Infection by Way of the Eustachian Tube.*—(1) Tuber-culous infiltration of the mucous membrane spreads up the tube to the tympanic cavity (*Fig.* 222), or (2) infectious particles may be insufflated up the Eustachian tube during the acts of coughing or sneezing. Inva-sion of the labyrinth occurs first of all through the oval and round windows (*Fig.* 223). In advanced cases there is caries and necrosis of the bony labyrinth capsule (*Fig.* 224). In rare cases there is a tendency to spontaneous cure of the tuberculous labyrinthitis (*Fig.* 225).

Infection by the Blood-stream.—If the Eustachian tube and tympanum appear to be healthy, while the mastoid process alone is diseased, the probability is that infection has occurred by way of the blood-stream.

SYMPTOMS.—The onset appears to be painless, in marked contrast to the early stages of pneumococcal or streptococcal otitis media. The lymph-glands surrounding the ear are often enlarged. In the early stage the discharge is watery, and later it may be flocculent ; in the advanced stages, where mixed infection is present, it is offensive and purulent. Paralysis of the facial nerve was present in 45 per cent of the cases recorded by Turner. Multiple perforations in the tympanic membrane may sometimes be seen in adults (*Plate XVI*, 8, p. 304). Beck holds that perforations of the anterior superior quadrant are often of tuberculous origin.
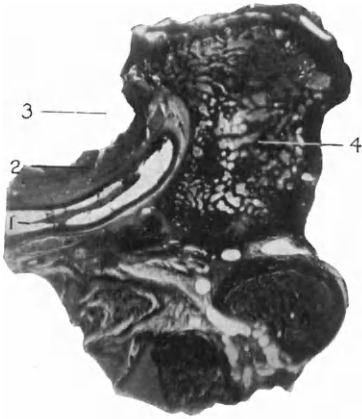
Fig. 222.—Advanced tuberculous disease of ear. Vertical coronal section through anterior part of petrous pyramid. (1) Internal carotid artery; (2) Tuberculous granulation tissue infiltrating wall of carotid; (3) Region of Eustachian tube—tube cannot be recognized; (4) Anterior part of petrous pyramid.

Fig. 223.—Early tuberculous disease of the ear. Showing invasion of vestibule through oval window; erosion of promontory; niche of round window filled with tuberculous granulation tissue. (1) Membrane of round window; (2) Tuberculous erosion of promontory; (3) Head of stapes; (4) Tuberculous tissue in niche of oval window; (5) Facial nerve; (6) Vestibular nerve to utricle and lateral and superior canals; (7) Footplate of stapes, eroded and displaced towards vestibule; (8) Vestibular nerve to ampulla of posterior canal; (9) Tuberculous tissue filling up niche of round window.

Fig. 224.—Advanced tuberculous disease of the ear. Vertical coronal section through cochlea, showing fistulæ into cochlea; cochlea is full of tuberculous granulation tissue. (1) Fistula into basal coil of cochlea; (2) Middle coil of cochlea—all scalæ filled with tuberculous granulation tissue, osseous spiral lamina still to be seen; (3) Fistula into apex of cochlea; (4) Cartilage-bone capsule of cochlea; (5) Lamellar bone surrounding cochlear capsule; (6) Tuberculous pachymeningitis in floor of middle cranial fossa; (7) Facial nerve; (8) Auditory nerve; (9) Cellular infiltration in fundus of internal meatus.

Fig. 225.—Child, age 9 months. Fibroossifying type of tuberculous otitis. Vertical section of left inner ear. (1) Cochlear nerve in internal meatus infiltrated by tubercle; (2) Small-cell infiltration in fundus of internal meatus; (3) Dilatation of cochlear canal in middle coil; (4) New formation of fibrous tissue and bone in scala vestibuli of middle coil; (5) Lamellar bone surrounding cochlear capsule; (6) Cartilage-bone capsule of cochlea; (7) Facial nerve; (8) Apical coil of cochlea; (9) Tuberculous erosion (fistula) in basal coil; (10) Basal coil filled by granulation tissue and new bone: (11) Niche of round window filled with tuberculous granulation tissue.

Involvement of the labyrinth (*Figs.* 223, 224, 225) is of frequent occurrence, and takes place at a comparatively early stage of the disease. Tuberculous labyrinthitis, like tuberculous otitis media, appears to have a quiet onset, in marked contrast to the violent symptoms produced by an attack of acute purulent 'manifest' labyrinthitis.

COMPLICATIONS.—Tuberculous otitis media and interna do not, as a rule, give rise to intracranial complications, though tuberculous pachymeningitis externa is frequently met with at operation. A number of cases, however, have been reported where a tuberculoma of the brain has occurred (Stewart). The cerebellum is the most favoured site; these tumours may be single or multiple. The majority of cases are only diagnosed at operation or may be entirely masked by a terminal tuberculous meningitis. The treatment consists in decompression for increased intracranial pressure symptoms combined with recognized general treatment, and extirpation of the growth should not be attempted. Tuberculomas heal by becoming calcified. Rupture of the internal carotid artery, with fatal hæmorrhage from the ear, is a rare complication of tuberculous otitis.

DIAGNOSIS.—This is made by attention to the following points :—

1. The clinical characteristics of the case already described.

2. Examination of the ear discharge for tubercle bacilli.

3. The findings at operation—enlarged caseous glands, presence of necrosed bone, pale flabby granulations, putty-like pus in the tympanic antrum, extensive caries of the bone, necrosis of the labyrinthine wall.

4. Microscopic examination of the swollen and infiltrated mucosa removed at operation.

5. Subcutaneous inoculation of the tissue obtained at operation into the groin of a guinea-pig. In order to get rid of mixed infection, this tissue may be previously treated with antiformin or ericolin.

PROPHYLAXIS.—It is obvious that great attention should be paid to obtaining a pure milk-supply.

TREATMENT.—In infants and young children it is advisable to operate at once, whenever the tuberculous nature of the disease is recognized, unless the condition of the child is obviously hopeless. In cases associated with phthisis pulmonalis operation should be carried out only if the patient suffers severe pain, as it is hopeless to get rid of all the disease.

The radical operation is indicated in all cases except those rare fungoid forms in which there is an apparently primary (hæmatogenous) involvement of the mastoid process. It is an advantage to expose the dura mater of the middle and posterior fossæ over a considerable area, as this membrane forms a much better barrier than the bone against the spread of tuberculous disease. Even the most extensive operation does not remove the last vestige of disease, e.g., in the Eustachian tube. One must therefore depend to a great extent on the resisting powers of the patient, and for this reason it is very important that sanatoria should be provided for the after-treatment of these cases along with other forms of 'surgical' tuberculosis. It is useless to send the children back to the slums from which so many of them come. Treatment by means of

artificial sunlight may be of benefit in these cases. After the mastoid operation benefit may result from the application of Pfannenstiel's method of treating tuberculosis of the nasal mucous membrane. Sodium iodide is given internally in increasing doses, and the operation cavity is packed each day with strips of gauze soaked in peroxide of hydrogen.

SYPHILIS OF THE EAR.

CONGENITAL SYPHILIS.

After epidemic cerebrospinal meningitis and middle ear suppuration, this condition ranks as the most frequent cause of acquired deaf-mutism. It is probable that many cases of so-called 'congenital' deaf-mutism are really due to intra-uterine syphilis or to syphilitic changes in the ear
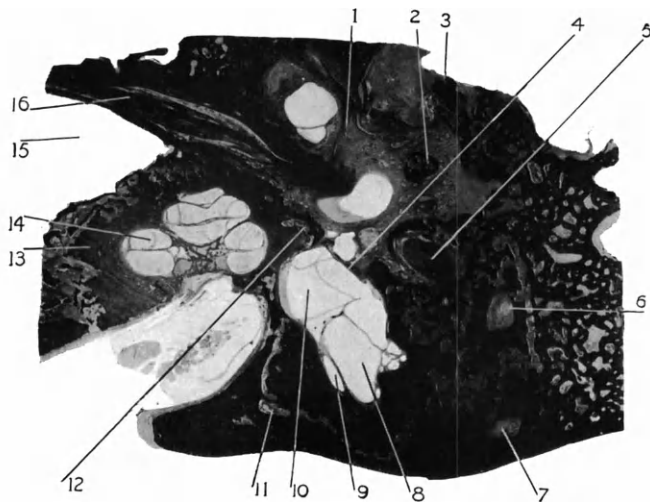
Fig. 226. *—Congenital syphilitic disease of the ear. Horizontal section through left ear. (1) Tendon of tensor tympani; (2) Long process of incus; (3) Necrosed bone being extruded into external meatus; (4) Footplate of stapes; (5) Facial nerve; (6) Lateral canal—perilymph space is filled with granulation tissue; (7) Posterior canal—also filled with granulation tissue; (8) Utricle; (9) Ductus endolymphaticus; (10) Dilated saccule; (11) Osteoclastic marrow which, higher up, erodes the internal meatus; (12) Osteoclastic marrow in bone of promontory in anterior margin of oval window; (13) Bony capsule of cochlea; (14) Dilated scala media of basal coil of cochlea; (15) Carotid canal; (16) Tensor tympani muscle. Note erosion of bony capsule of cochlea by the osteoclastic marrow.

occurring before the child has learned to talk. Statistics as to the frequency of deafness in children suffering from congenital syphilis vary from 30 to 60 per cent.

1. *In the Fœtus and Infant.*—Alexander states that the most severe forms of ear syphilis occur in intra-uterine life. The new-born infants

* *Figs.* 226–229 are sections from the ear of a male, age 20, a blind basket-maker. Father died of aneurysm at 35 ; mother had four still-born children before patient's birth. As a young child patient heard and spoke normally. At four years he had measles, followed by double otorrhœa, which persisted. Deafness gradually increased. At ten years he had interstitial keratitis, and six months later syphilitic ulceration of the pharynx. Within a year deafness became almost complete. Speech became very indistinct. He walked-in a peculiar 'rolling' manner.

show all the signs of congenital deafness, and the static labyrinth is not excitable.   Otitis media is of common occurrence in syphilitic infants. In some the infective process involves the labyrinth by rupture of the annular ligament.

2. *In Young Children* suffering from congenital syphilis, what appears to be a case of simple Eustachian catarrh runs an unfavourable course (McBride).   Treatment has no good effect, and the drumheads remain thickened and indrawn, while the deafness is severe and persists.   There is a combination of middle ear catarrh and labyrinthine deafness.

3. *The Late Type of Congenital Syphilis*, where deafness occurs usually between the seventh and thirteenth years, may be due to: (*a*) Otitis media followed by invasion of the labyrinth capsule and degeneration of

Fig. 227.—Congenital syphilitic disease of the ear. (1) Carotid canal ; (2) Area of osteomyelitis in capsule of cochlea between cartilage and lamellar bone ; (3) Dilated cochlear duct of middle coil ; (4) Dilated cochlear duct of basal coil.

the membranous labyrinth (*Figs.* 226, 227, 228, 229).   In cases of congenital syphilitic deafness the tympanic membranes are seldom normal,
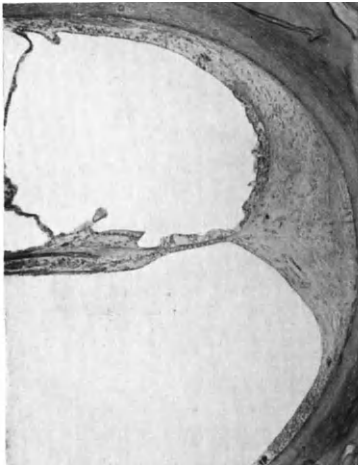
Fig. 228.—Congenital syphilitic disease of the ear. Shows the condition (degenerative neuritis) of Corti's organ in the basal coil. (Compare with *Fig.* 165, p. 269.)

Fig. 229.—Congenital syphilitic disease of the ear. Spiral ganglion of the basal coil, showing atrophy of nerve-cells.

pointing to a past attack (or attacks) of otitis media.   (*b*) Syphilitic osteomyelitis of the bony labyrinth capsule due to spirochætal blood infection (Otto Mayer).   (*c*) Syphilitic neuritis of cochlear nerve.

CLINICAL ASPECT.—The patient is very often the eldest living child of the family and, on questioning the mother, a history is often obtained of miscarriages and still-births preceding the birth of the patient. Females are affected much more frequently than males. As a rule the eye trouble (interstitial keratitis) comes on two or three years before the deafness. 'Hutchinson' teeth (peg-shaped, notched incisors) are present in 50 per cent of cases (*see Fig.* 42). Deafness may come on in one night (apoplectiform type of Gradenigo) : in such cases the rotation test gives normal results, thus pointing to an isolated affection of the cochlear nerve. In other cases the onset of deafness is gradual, but eventually the patient becomes completely or almost completely deaf.

Cochlear Apparatus.—In the early stages the deafness is probably of the middle ear type. As a rule, however, the case is not seen till later, when bone-conduction is greatly shortened and may be absent. The watch is not heard by bone- or air-conduction. The upper tone-limit is much reduced, while the lower tone-limit is raised.

Vestibular Apparatus.—Of 24 cases examined, the vestibular reaction was absent in 14, reduced in 7, and normal in only 4. Hennebert has called attention to the presence of 'compression' nystagmus (fistula symptom) in some cases of congenital syphilitic disease of the ear. Bárány holds that this is due to excessive mobility of the stapes.

In cases of congenital origin the cerebrospinal fluid is practically always normal, and the seat of the lesion is therefore most likely in the labyrinth. Both ears are usually affected, and the patients are often deaf-mutes.

DIAGNOSIS.—Very marked or complete deafness in a child should always make the observer think of congenital syphilis. Suspected cases should be examined for the presence of interstitial keratitis, 'Hutchinson' teeth (*Fig.* 42), ozæna, saddle-back nose, perforation of the nasal septum, and scars on the palate, pharynx, and at the angles of the mouth. The patient's mother should be questioned as to miscarriages and still-births. In doubtful cases the Wassermann reaction should be tested, but even if this is negative, as it often is in adults, the case may still be one of congenital syphilitic origin.

TREATMENT.—*See*

ACQUIRED SYPHILIS.

External Ear.—1. Primary syphilis of the outer ear is rare. The disease may be inoculated by kissing, biting, the use of infected towels, or by piercing the lobule with infected instruments.

2. Secondary syphilitic affections (condylomata and papules) of the external ear and meatus are more common, and may be associated with middle ear suppuration.

Middle Ear.—Primary chancre at the orifice of the Eustachian tube was sometimes seen in pre-antiseptic days, when unsterilized vulcanite catheters were transferred from an infected nose to a healthy one. Secondary syphilis is probably much more common than is usually supposed. Syphilitic nasopharyngitis may spread up to the tympanum

and give rise to catarrhal otitis media. The labyrinth is often affected in these cases. As a rule one ear is involved. The onset of deafness is usually rapid, but the pain is slight. Tinnitus is marked and giddiness may be present. Inflation produces no improvement in hearing. Syphilitic otitis media in the tertiary stage is usually due to an affection of the nasopharynx—gumma or ulceration. Caries and necrosis of the tympanic walls may be present, associated with facial paralysis and labyrinthitis (syphilitic panotitis).

Labyrinth and Eighth Nerve : '*Neurolabyrinthitis*'.—Beck finds that in 80 per cent of syphilitic patients the bone-conduction is more or less shortened, although the hearing is normal. He attributes this to raised intracranial pressure. In the early stages of syphilis there is often a pleocytosis in the cerebrospinal fluid along with an increase of albumin, i.e., a luetic meningitis. After lumbar puncture, the shortening of the bone-conduction disappears for a time. Cases in which the primary sore is still present and the Wassermann reaction is negative sometimes show this shortened bone-conduction, which, however, as a rule only appears with the constitutional symptoms. The sign may be of value in the diagnosis of syphilis, especially if found in conjunction with diminished or absent reaction to rotation in the presence of a normal caloric response. In secondary syphilis complaints of tinnitus, giddiness and disturbance of balancing are by no means rare. In some there are changes in the posterior cranial fossa, as evidenced by nystagmus of central origin and cerebellar disturbance of balancing. These cases nearly all show definite changes in the cerebrospinal fluid, i.e., positive Wassermann reaction and increased cell-count. Deafness is sometimes of sudden onset, but may be gradual. As a rule only one ear is involved. Functional examination shows an inner ear deafness and microscopic examination of the labyrinth reveals atrophy of Corti's organ and its ganglion cells. According to Roosa, diplacusis, i.e., hearing the same tone as of different pitch in the two ears, is a common symptom of syphilitic disease of the eighth nerve.

Tertiary Affections of the Eighth Nerve.—The eighth nerve may be affected, along with other cranial nerves, by gummatous infiltration of the meninges and nerve sheaths. These conditions are often preceded by severe headache, sometimes of long duration. Beck points out that headache of syphilitic origin is worst at midnight, while that of nasal origin is most severe in the forenoon. In cases of nerve deafness, when the patients are below 60 years of age, the Wassermann reaction of the cerebrospinal fluid is often positive. These patients are suffering from a syphilitic affection of the nervous system. Beck states that an affection of the cochlear nerve may be an early symptom of tabes.

TREATMENT.—Prevention of syphilitic deafness would be much more satisfactory than the more or less unsuccessful attempts to cure syphilitic ear affections once they have occurred. Salvarsan has proved very disappointing in the treatment of ear syphilis—indeed, many regard it as a frequent source of ear troubles. (*See also* DEAFNESS DUE TO DRUGS, p. 424.) Alexander and others hold that it is dangerous to give salvarsan alone if there is any affection of the auditory nerve

apparatus. Mercurial treatment should always be combined with it. In severe cases of syphilitic neuro-labyrinthitis mercurial treatment alone is to be preferred. Mott points out that spirochætes find a safe retreat in the cerebrospinal fluid and are eliminated with great difficulty, because mercury and arsenic do not pass through the choroid plexus. Neumann has recently treated syphilitic affections of the labyrinth and eighth nerve by the inoculation of malaria, followed by injections of arsenical compounds. Brisotto claims good results from the use of bismuth preparations. In congenital syphilis, Findlay and Robertson hold that antenatal treatment gives the best results.

One of the great difficulties in treating congenital syphilitic ear disease is the fact that children are seldom brought when the deafness first comes on. As a rule a period of months or even years elapse before the cases are seen. If the condition were diagnosed at once by the patient's doctor, the prognosis might be somewhat better. It must be admitted, however, that several cases are on record in which deafness appeared while the child was undergoing mercurial treatment on account of the eye trouble. Wanner advises inunction of mercury combined with the administration of potassium iodide. Cheatle states that if thyroid extract is given along with mercury and iodide a better result may be obtained. Alexander favours the use of mercurial injections followed by salvarsan. Dench has found that in some cases injections of pilocarpine are of great benefit. On the whole, it must be admitted that treatment appears to be of little value. It is very important, however, that the speech already acquired should be retained, and therefore the child should, as soon as possible, be admitted to a deaf-mute school for education by the oral method. It is surprising how quickly a child, once it has ceased to hear, loses its speech unless suitable training is begun at once.

MALIGNANT DISEASE OF THE EAR.

Auricle.—Malignant disease of the auricle is almost entirely confined to males. Most of the cases are epitheliomatous, only 25 per cent being of the basal-cell type. Carcinomata often develop from seborrhœic keratosis and frost-bites, or become superimposed upon a lupus, and usually affect the upper part of the helix on its medial or posterior aspect. A small superficial ulcer forms and heals slowly, the scab being deliberately scratched or accidentally rubbed off. The patient first complains of itching and burning, later of throbbing pain which involves the side of the head and is only relieved by narcotics.

TREATMENT.—To guard against the condition the auricles should be suitably protected and slight injuries should receive surgical attention. Seborrhœic keratosis may be treated by salicylic ointment (10 per cent) or carbon-dioxide snow. Röntgen-ray or radium applications are also recommended. In growths of the prickle-cell type, early and radical excision with the diathermy knife, or by removal of a wedge-shaped piece including the whole thickness of the auricle, should be employed. The edges are united, and as a rule the ensuing deformity is slight.

External Acoustic Meatus.—Squamous epithelioma begins as a small ulcer covered by a horny layer, usually in the cartilaginous part of the meatus near its junction with the bony portion. The patient complains of considerable discomfort and irritation ; later of severe pain, worse at night, and scanty sero-sanguineous discharge. If the surgeon applies a pledget of cotton-wool soaked in bicarbonate of soda solution, the horny covering is easily removed and the subjacent ulcer exposed. Before proceeding to operate, the surgeon may, with the aid of local anæsthesia, excise a piece of the growth for microscopic diagnosis. Even in the case of a small growth, operations should involve complete removal of the cartilaginous and membranous meatus through an incision in the retro-auricular groove. The resulting cavity is lined by a Thiersch skin-graft from the patient's thigh. The graft is kept in position by packing the meatus with iodoform worsted.

In advanced cases with occlusion of the external meatus by a fungating malignant growth, associated with hæmorrhage, fœtor, excruciating pain. and facial paralysis, operation is useless. Deep X-ray therapy should be employed. Hypodermic injections of morphia are required.

Middle Ear.—Malignant disease rarely affects the middle ear, though both carcinoma and sarcoma are occasionally met with, the former in the middle-aged and old, the latter most often in children ; in either case there is, as a rule, a history of chronic otorrhœa. Cancer of the middle ear is difficult to diagnose from epithelioma commencing in the deeper part of the external meatus. Malignant disease is usually associated with severe pain in the ear, copious and generally very fœtid secretion, and exuberant granulations which bleed readily and recur rapidly after removal. Cachexia is often well marked. Facial paralysis is, as a rule, an early sign, but the cervical lymphatic glands are not usually involved. Labyrinthine symptoms such as giddiness and nausea may be present. Death takes place from exhaustion, meningitis, lateral sinus thrombosis, brain abscess, or direct extension of the growth to the vital centres in the brain.

DIAGNOSIS.—When malignant disease is suspected, e.g., when the granulations recur rapidly after removal in a patient past middle life, the diagnosis may be confirmed by microscopic examination of the granulation tissue.

PROGNOSIS.—This is bad. The interval from the first symptom to the time of death varies from eight to eighteen months.

TREATMENT.—If possible, the disease must be eradicated by operation, which reveals extensive destruction of bone and sequestrum formation ; some information of its extent may be obtained beforehand by taking a radiogram. Operative procedures usually relieve- the pain if only for a time : they may be followed by a vigorous application of radium, or by X-ray treatment.

CHAPTER XLI.

THE LABYRINTH AND EIGHTH NERVE.

IN considering diseases of the labyrinth, it must be remembered that that organ consists of two distinct structures : (1) The *Vestibular apparatus* (utricle, and semicircular canals) ; and (2) The *Cochlea*. The former is the peripheral organ of equilibration, the latter of hearing. Disturbances of the vestibular apparatus produce giddiness, nausea, vomiting, loss of balancing, and nystagmus, while affections of the cochlea result in deafness and tinnitus.

CONGENITAL DEFECTS.

Congenital defects of the labyrinth are responsible for the condition known as **sporadic congenital deaf-mutism.** Complete absence of the labyrinth has been described. Both the bony and membranous cochlea may be malformed. As a rule, however, only the membranous cochlea and saccule are involved, the utricle and semicircular canals being normal (*Figs.* 230, 231). In the great majority of cases both ears are affected, and accordingly the child becomes a deaf-mute (*see* DEAF-MUTISM, p. 431).

Kerr Love holds that hereditary deafness is Mendelian in incidence, and draws a parallel between human beings and peas. A pure tall may be crossed with a hybrid tall, and then all the resulting generation are tall, though half are hybrid. As long as hybrids meet pure talls, only talls will result. But whenever a hybrid meets another hybrid or a dwarf, then the dwarfs appear. So it probably is with deafness. If hearing people carrying deafness marry pure hearing people, no deafness results. But if by chance—and the chance is bound to come—two hybrids (hearing people carrying deafness) marry, deaf children must follow.

	NATURE OF UNION			RESULT	
No.	H.H. means pure hearing : D.D. means pure deaf : H.D. means hybrid hearing, i.e., hearing individuals who carry deafness	Pure hearing children	Hybrid hearing children carrying deafness	Deaf children
1	H.H. × H.H.	100	—	—
2	D.D. × D.D.	—	—	100
3	H.H. × D.D.	—	100	—
4	H.D. × H.D.	25	50	25
5	H.D. × H.H.	50	50	—
6	H.D. × D.D.	—	50	50
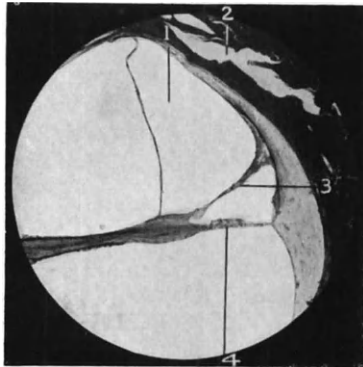
Fig. 230.—Congenital deaf-mutism due to faulty development of membranous cochlea. Horizontal section through upper part of left basal coil. (1) Dilated cochlear duct ; (2) Split in bony capsule (artefact) ; (3) Adhesion between membrana tectoria and stria vascularis : (4) Rudimentary Corti's organ.
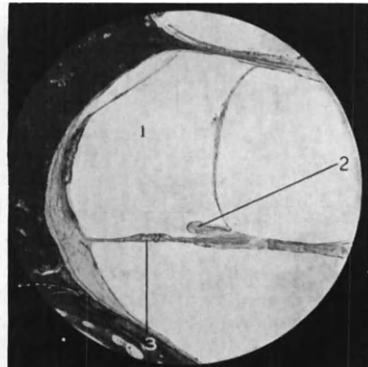
Fig. 231.—Same case as Figs. 230, 232, 233. Horizontal section through lower part of left middle coil. (1) Dilated cochlear duct ; (2) Membrana tectoria lying on the apex of the limbus ; (3) Rudimentary Corti's organ. The spiral ligament shows dropsical degeneration. The stria vascularis appears to be well formed.
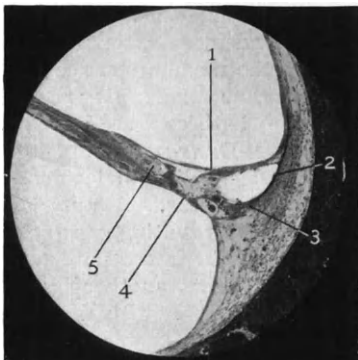
Fig. 232.—Same case as Figs. 230, 231, 233. Vertical section through upper part of right basal coil. (1) Reissner's membrane depressed and attached to malformed Corti's organ; (2) Position of stria vascularis, which is absent ; (3) Position of spiral prominence ; (4) Basilar membrane ; (5) Membrana tectoria tucked into internal spiral sulcus. It will be seen that there is a complete malformation of the epithelium lining the cochlear canal.
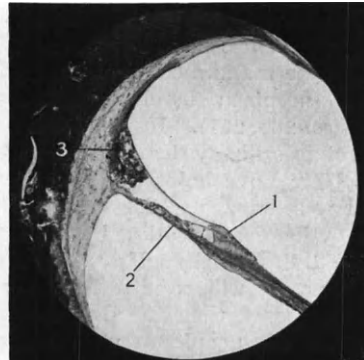
Fig. 233.—Same case as Figs. 230, 231, 232. Vertical section through lower part of right middle coil. (1) Membrana tectoria, which lies between the origin of Reissner's membrane and the limbus ; (2) Rudimentary Corti's organ ; (3) Great proliferation of stria vascularis, which occupies the outer third of the narrow cochlear canal.

Class I (*see* Table, p. 411).—A hearing man, both of whose parents heard and did not carry hereditary deafness, marries a similar woman. No congenitally deaf children can result. This is the case in far more than ninety of every hundred marriages. *Class II.*—A deaf man, both of whose parents are hereditarily deaf, marries a similar woman, and all their children are deaf. This kind of union has occurred. *Class III.*—A pure hearing person marries a pure deaf-mute, and all the children hear. In Mendelian terms, hearing is

dominant to deafness, which is recessive. Deafness, however, may be present in the grandchildren. *Class IV.*—A hearing man carrying deafness marries a hearing wife carrying deafness, and both deaf and hearing children follow. The parents were hybrids like the first hybrid generation of tall peas. Deaf children *must* follow if the family is large. *Class V.*– A hearing man carrying deafness marries a pure hearing woman, and no deaf children result. But half the children will carry deafness, and if any of these wander into *Classes II, III, IV,* or *VI*—and they are sure to wander there unless guided by the kind of knowledge Mendelism gives us—deaf children will result. If these hybrids were always to marry pure hearing partners, no deaf children would ever follow. But this kind of marriage (*Class V*) is common, and accounts for many of the puzzling cases of sporadic congenital deafness. *Class VI.*—A hearing man carrying deafness marries a pure deaf woman. Half the children are deaf, and all the children carry deafness. This is a common type of marriage amongst the deaf, because the deaf and their hearing relatives are necessarily thrown much together. (*See* DEAF-MUTISM, p. 431.)

Endemic Congenital Deaf-mutism is common in Switzerland and is associated with goitre and cretinism. The pathological changes mainly affect the middle ear—the window niches being narrow or occluded and the stapes more or less immobile. In many cases, however, deaf-mutism probably depends mainly on the poor mental development of the child. (*See* DEAF-MUTISM, p. 431.)

TRAUMATIC AFFECTIONS OF THE AUDITORY NERVE AND LABYRINTH.

Direct Injury.—The labyrinth may be affected as the result of direct injuries, such as ill-directed attempts to remove a foreign body, or by the passage of a sharp implement, such as a knitting-needle, through the external auditory meatus and the oval window, into the inner ear. Deafness, giddiness and nausea supervene at once, facial paralysis is also met with, and acute labyrinth suppuration may result. The local treatment is the same as in the case of injuries to the middle ear (*see* p. 323). Rest in bed is indicated as long as the giddiness lasts. (*See* LABYRINTHITIS, p. 366).

Indirect Injury.—Blows or falls on the head may be followed by deafness, which is due to concussion of the labyrinth, or to fracture of the labyrinth capsule with hæmorrhage into the peri- and endolymph spaces. Fractures of the base of the skull involving the temporal bone are followed by deafness which is often permanent. The middle fossa is most frequently involved in fractures of the base of the skull and this is due to the line of weakness which exists by the union of the basi-occipital and basi-sphenoid from the Glaserian fissure to the foramen lacerum. The Eustachian tube, canal for tensor tympani, tympanum and tympanic antrum are intimately connected with this line. Biechele divides fractures of the petrous bone into two main groups : (1) Longitudinal fractures which are the most common. The fracture line runs from the squamous portion of the temporal bone across the tegmen tympani to the anterior edge of the petrous pyramid and ends in one of the foramina of the middle cranial fossa. The tympanic membrane is generally torn ; the labyrinth as a rule escapes injury. (2) Transverse

fractures in which the break is at right angles to the long axis of the petrous bone and crosses the inner ear with injury of the bony and membranous labyrinth. The middle ear and the tympanic membrane may remain intact so that there is no hæmorrhage from the meatus. A peripheral paralysis of the facial nerve has been recorded in about 46 per cent of fractures of the middle fossa of the skull and almost all the cases which survived were of the middle-ear type of deafness (Davis). Therefore the prognosis of cases in which the labyrinth capsule is involved is extremely grave. In all cases of suspected fracture a thorough examination of the ear, nose and throat should be carried out. A radiogram may show that the fracture involves the temporal bone. Giddiness and tinnitus may accompany the deafness, but the giddiness usually disappears after a time. Bleeding from the external

Fig. 234.—Fracture of cranial base without injury to labyrinth capsule. Horizontal section through right ear. (1) Malleus; (2) Incus surrounded by blood-clot; (3) Facial nerve; (4) The two ends of the posterior vertical canal; (5) Hæmorrhage in branch of vestibular nerve to ampulla of posterior canal; (6) Hæmorrhage in fundus of internal meatus; (7) Hæmorrhage in Eustachian tube. (× 3.)
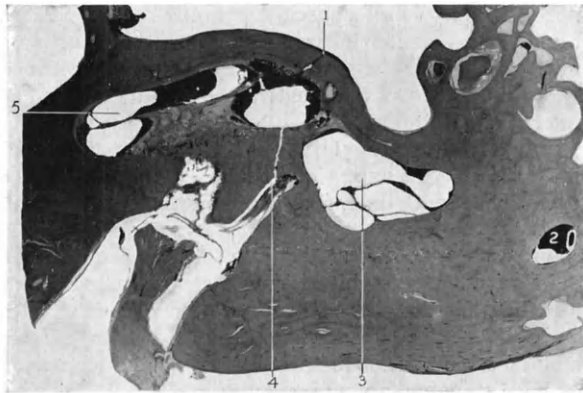
Fig. 235.—Fracture of cranial base with injury to labyrinth capsule. Horizontal section through right ear just above round window. (1) Fracture of promontory; (2) Both peri- and endolymph spaces of posterior canal contain blood; (3) Vestibule with slight hæmorrhage; (4) Line of fracture reaches the canal for nerve to ampulla of posterior semicircular canal; (5) Basal coil of cochlea with hæmorrhage in all three scalæ. (× 5.)

meatus is usually met with, but in rare cases the drumhead remains intact and presents a blue-black appearance (hæmato-tympanum). If blood

alone is present in the meatus, the prognosis from the otological point of view is better, because it is probable that only the walls of the middle ear have been involved (*Fig.* 234). If, however, both blood and cerebrospinal fluid flow from the ear, the labyrinth capsule has been injured (*Fig.* 235), and permanent deafness will result if the patient recovers. In many cases infection is superadded to the injury— either from the nasopharynx through the auditory tube (Eustachian) or from the external meatus—with the result that purulent leptomeningitis supervenes (*Fig.* 236). Patients who have recovered from fracture of the temporal bone are predisposed, if they get an acute otitis media, to suffer from meningitis, the infection in these cases passing

Fig. 236.—Male, age 44, fell, striking the right side of his head. Concussion and bleeding from right ear and also from mouth. Severe headache and feeling of rotation about a vertical axis. Right ear quite deaf. Nausea but no vomiting. Spontaneous nystagmus to left (sound) side. Patient fell to right and showed a pointing error to right. Temperature 105°. Pulse only 72. Kernig's sign present. Facial paralysis (right). *Post-mortem.*—Purulent leptomeningitis at base of brain. (1) Fracture; (2) Exudate in vestibule; (3) Fracture of bony spiral lamina; (4) Scala tympani; (5) Fracture of tympanic floor; (6) Exudate in tympanum; (7) Perforation of drumhead; (8) Fracture of meatal wall.

to the meninges along the line of the old fracture (Nager).

Fig. 237.—High-explosive shell injury of ear. Horizontal section. Shows rupture of anterior part of drumhead, with everted edges. (1) Anterior portion of ruptured drumhead (everted); (2) Posterior margin of rupture, also everted; (3) Malleus; (4) Facial nerve, with stapedius to the left; (5) Smooth end of posterior vertical part; (6) Lower part of utricle, with crista quarta; (7) Internal meatus; (8) Carotid canal; (9) Tubal part of tympanum.

TREATMENT.—The general treatment of fracture of the base need not be discussed here. If there is no bleeding from the ear the meatus should be painted with tincture of iodine. If hæmorrhage be profuse the auricle should be carefully cleansed and a strip of iodoform gauze inserted.

The meatus must not be syringed. If middle ear suppuration has been present previously, and if cerebrospinal fluid be noted along with blood in the meatal

discharge, following a fracture of the base, Jenkins advises free drainage even to the extent of performing the radical mastoid operation with exposure of the dura mater along the line of fracture. Ballance advises trephining the squamous temporal bone in cases of compression.

'Explosion' Deafness.—Both cochlear and vestibular organs may be damaged by explosion but the vulnerability of the cochlea is much greater. During the war many cases of labyrinthine deafness due to high explosives came under observation. Often the patients suffered from shock, and presented all the symptoms of nerve deafness. As a rule the deafness and tinnitus diminished in the weeks following the injury. Spontaneous nystagmus to the sound side rapidly passed off, while vertigo and disturbances of equilibrium disappeared in a few weeks. More or less deafness, however, remained. Not uncommonly, in addition to hæmorrhage into the nerve and labyrinth, the tympanic membrane was ruptured (*Figs.* 237, 238). Middle ear suppuration sometimes followed.
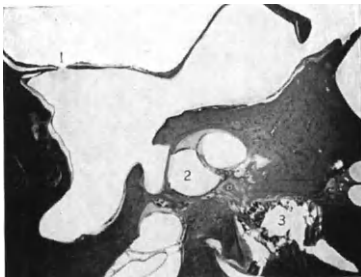
Fig. 238.—Injury to left ear due to explosion of rifle grenade. Horizontal section. (1) Rupture of drumhead, with blood-clot on anterior margin; (2) Scala tympani just internal to round window membrane, with thin layer of hæmorrhage on the walls: (3) Fundus of internal meatus with hæmorrhage.

Treatment consists in complete rest, low diet and administration of bromides or of small doses of potassium iodide. Holmgren has observed great improvement in hearing after lumbar puncture. In a certain number of cases a functional element was present, especially in those in which examination of the vestibular apparatus showed normal reactions. It must not, however, be taken for granted that deafness — especially when only moderate in amount—in the presence of normal vestibular responses is necessarily functional. The cochlear apparatus lies between the oval and round windows, and it is thus more sensitive to violent commotion of the atmosphere than the vestibular structures. (*See also* HYSTERICAL DEAFNESS, p. 429.)

'Noise' Deafness.—Constant exposure to loud noises is a well-known cause of labyrinthine deafness. It is met with in boiler-makers, coopers, factory workers, artillerymen and sailors in the Royal Navy. Miners and others who use pneumatic or electric drills are also affected. The deafness is due to degeneration of the cochlear apparatus, beginning in the spiral ganglion and later affecting Corti's organ. The level of the damage in the cochlea depends on the pitch of the sound (Yoshii). Most observers hold that the affection is due to air-conduction of the sound. Rodger considers that the pathological condition present is an exhaustion atrophy from over-excitation affecting primarily that part of the cochlear duct which corresponds to the prevailing sound. Thus in engineering shops even comparatively young men may show some degree of deafness for sounds between 419 and 512 d.v.s., though their hearing for low and high tones is normal. In railwaymen exposed to the shriek of

the engine whistle Putelli found injury to the part of the cochlea concerned in the perception of high tones (C 2048 and C 4096). The deafness increases gradually and is not as a rule accompanied by tinnitus. Men who use a sporting gun occasionally suffer from deafness in one ear—as a rule the left, as sportsmen usually shoot from the right shoulder.

TREATMENT.—Treatment in all these cases is unavailing, but as a prophylactic measure a plug of cotton-wool smeared with vaseline, or one made with jeweller's wax, should be worn in the ears during exposure to the noises. The great difficulty is to get workmen to use the plugs regularly, the opinion among them being a fixed one that nothing will prevent the deafness. Rodger suggests that it should be made incumbent on foremen to see that preventive measures are regularly used. Artillery-men may wear obturators which prevent concussion during gun-fire but permit of hearing conversation.

Caisson Disease.—Caisson workers are liable to nerve deafness if com-pression or decompression is carried out too rapidly. The symptoms manifest themselves after the patient has left the caisson ; the onset is acute, the deafness being accompanied by giddiness, tinnitus and vomiting. The deafness is rarely permanent. The pathological changes are due either to a hæmorrhage into the labyrinth or to air emboli form-ing in the blood and reaching the labyrinth. Airmen, mountaineers and divers are liable to similar lesions.

INFLAMMATORY AFFECTIONS OF LABYRINTH (Labyrinthitis).

Labyrinthitis secondary to middle ear inflammation has already been dealt with (p. 362).

Meningitic Neurolabyrinthitis.—Though the majority of cases of laby-rynthitis result from middle ear suppuration, a considerable minority are due to leptomeningitis. Meningitic neurolabyrinthitis is a frequent cause of deafness and deaf-mutism, e.g., deafness after epidemic cerebrospinal meningitis is due to this cause. Measles and pneumonia may also be followed by meningitis and secondary neurolabyrinthitis. In acquired syphilis and mumps, leptomeningitis is sometimes met with, and is associated with inner-ear deafness, which is probably to be explained by neuritis or neurolabyrinthitis. Certain cases of deafness after influenza and osteomyelitis may also be of meningitic origin. The original source of infection may be in the respiratory tract, parotid gland, genital organs, long bones or elsewhere. A blood infection (septicæmia) probably forms the connecting link between the primary disease and the onset of menin-gitis. Meningitic neurolabyrinthitis is generally, but by no means always, bilateral. The onset is usually sudden. Irritative symptoms, such as tinnitus, nystagmus and giddiness, are present, but may not be observed owing to the mental condition (coma) of the patient. In epidemic cerebro-spinal meningitis and parotitis, deafness, if it occurs, usually comes on early in the course of the disease. Deafness due to meningitic neuro-labyrinthitis may be associated with other metastatic lesions, e.g., orchitis, arthritis, mastitis, blindness or paralysis of the oculomotor nerves.

27

The infection usually passes along the subarachnoid space from the base of the brain into the internal auditory meatus, and then along the nerves and vessels to the labyrinth. In some cases the perilymphatic aqueduct is the route of invasion, while in others both paths may be involved. As a rule both the cochlear and vestibular apparatus are affected. Frequently the cochlear apparatus alone is involved ; rarely do we have a more or less isolated affection of the vestibular apparatus. The pathological changes producing the deafness may be :—

1. Hydrocephalus.

2. Changes in the walls of the fourth ventricle.

3. Purulent infiltration of the eighth nerve, with subsequent descending neuritis accompanied by atrophy of the spiral ganglion.

4. Purulent labyrinthitis (*Figs.* 239, 240), which, if the patient lives long enough, is followed by the formation of granulation tissue and,
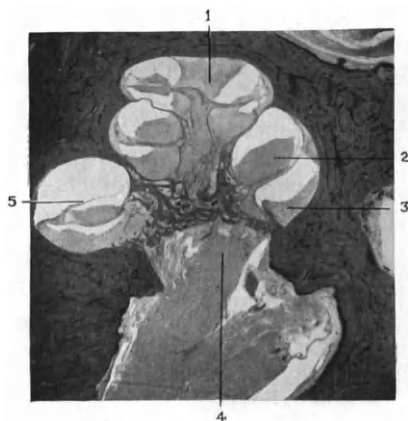
Fig. 239. — Meningitic neurolabyrinthitis. Pus is invading the cochlea along the branches of the cochlear nerve from the internal meatus. (1) Purulent exudate in helicotrema ; (2) Exudate in scala vestibuli ; (3) Same in scala tympani ; (4) Cochlear nerve with hæmorrhagic purulent exudate around ; (5) Endosteum detached from wall of scala tympani of basal coil (artefact).
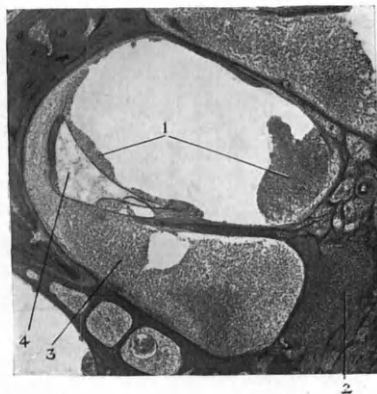
Fig. 240.—Meningitic neurolabyrinthitis following pneumonia. (1) Purulent exudate in scala vestibuli—to the left it is lying on the upper surface of Reissner's membrane ; (2) Spiral ganglion infiltrated with pus ; (3) Scala tympani full of pus ; (4) Cochlear canal with fibrinous and slightly purulent exudate.

later, of new connective tissue and bone in the hollow spaces of the labyrinth. The resulting deafness is complete and permanent in the ear (or ears) affected.

After recovery the vestibular symptoms (loss of balancing and waddling gait) pass off rapidly in adults, but in young children they may last as long as one year. In cases of sudden nerve deafness, with or without vestibular symptoms, lumbar puncture should be performed and the cerebrospinal fluid examined chemically and microscopically. The Wassermann reaction of the fluid should also be tested and cultures made. Repeated lumbar punctures are of use in treatment, especially in cases of deafness due to hydrocephalus. Small doses of potassium

iodide and hypodermic injections of pilocarpine have been used in the treatment of meningitic neurolabyrinthitis, but apparently without success.

TUBERCULOUS AND SYPHILITIC AFFECTIONS OF THE INTERNAL EAR.

These are described in Chapter *XL.*

MÉNIÈRE'S SYMPTOM COMPLEX.

Ménière's symptom complex includes deafness and tinnitus (cochlear apparatus) as well as vertigo, loss of balancing, nystagmus, nausea and vomiting (vestibular apparatus). Each apparatus may be affected separately but the complete syndrome is present only when both are involved.

Ruttin has pointed out that, as the lymphatic spaces of the inner ear are continuous, it is almost impossible to conceive of an isolated affection of the cochlear or vestibular apparatus arising within the labyrinth itself. On the other hand, the cochlear and vestibular nerves may be affected separately by toxins which have a special affinity for one or other division.

Sydney Scott states that vertigo is the state of consciousness of a false sense of orientation of ourselves in relation to our environment. The patient feels "as if" he were moving or "as if" his surroundings moved, while realizing that such interferences are really erroneous. If the attack is severe the patient staggers and unless he can grasp some fixed object he may fall.

Ménière, in 1861, described the case of a young girl who, after a cold drive during her menstrual period,

Fig. 241.—Male, age 65, was exposed to severe cold on Dec. 1, 1917. Next morning he woke up suffering from extreme giddiness and from deafness and noises in left ear. The left side of the face was paralysed. External objects appeared to be moving around him. Nerve deafness on left side. Arteriosclerosis present. Diagnosis of neuritis of facial and auditory nerves made by the late Dr. Alexander Bruce. Patient died from syncope, five months after onset. Microscopic examination showed that the labyrinth was normal, but small-celled infiltration was present around the 7th and 8th nerves in the internal meatus. (1) Cellular infiltration beneath epineurium of seventh nerve; (2) Thickened artery; (3) Cellular infiltration around vestibular ganglion; (4) Artery.

was attacked by sudden deafness, intense giddiness and vomiting. She died on the fifth day of her illness, and at the autopsy it was found that the semicircular canals and the vestibule contained hæmorrhagic exudate. The cause of death was not discovered. Dan McKenzie is very doubtful about the authenticity of this famous case.

Ménière's syndrome in whole or in part may be due to :—

A. Local Causes.—(1) A plug of wax in the ear (very rarely). (2) Obstruction of one Eustachian tube producing inequality of pressure in

the two labyrinths. For this reason airmen and sailors in submarines require very careful examination in regard to the condition of the ears, nose and pharynx. (3) Otitis media, catarrhal or purulent. (4) Circumscribed labyrinthitis (p. 364). (5) Acute purulent labyrinthitis (p. 366). (6) Injuries of the inner ear (p. 413). (7) Hæmorrhage into the labyrinth in bleeding diseases—leukæmia and pernicious anæmia. (Note that this was formerly thought to be the usual cause of Ménière's syndrome, but such cases are very uncommon.) (8) Spasm of the internal auditory artery. The intermittent character of the vertigo and other symptoms point to a vasomotor origin. (9) Toxic neuritis or neuro-labyrinthitis arising from (a) excess of alcohol or tobacco ; (b) a focus of infection in connection with the teeth, tonsils, paranasal sinuses or genito-urinary tract ; (c) gastro-intestinal disturbances, e.g., constipation, intestinal auto-intoxication, ptomaine poisoning, etc. ; (d) nephritis ; (e) drugs, e.g., salicylates, quinine. (10) Syphilitic diseases of the ear (p. 405). (11) Œdema of the labyrinth, " glaucoma of the inner ear " (Milligan). Mygind and Dederding describe a form of Ménière's syndrome associated with urticaria, vasomotor rhinitis and angioneurotic œdema. Duke reports two cases of Ménière's syndrome due to taking certain articles of diet. (12) Tumour of the eighth nerve or cerebellopontine angle (p. 426).

B. Central or General Causes.—(1) Anæmia of the brain in cases of general anæmia or loss of blood. Patients during and after severe hæmorrhage complain of tinnitus and vertigo. (2) Endocrine disorders (Vernet). (3) Vascular spasm of the arteries of the brain in cases of cerebral arteriosclerosis. (4) Localized serous meningitis in the posterior cranial fossa (p. 371). (5) Thrombosis of arteries supplying the pons, medulla or cerebellum. (6) Syphilitic affections of the brain stem or gumma of the cranial base. (7) Functional disturbance of the medullary nuclei or cortical centres allied to migraine, epilepsy or asthma (Sargent, Thornval). Vertigo may occur as an aura of an epileptic attack or may replace the seizure (Gordon Holmes). (8) Cerebellar tumours (in this case deafness and tinnitus are usually absent).

Increased tinnitus, a feeling of pressure in the head and general depression may precede the Ménière syndrome. A typical attack is ushered in by a feeling of sea-sickness, which often gives sufficient warning to enable the patient to lie down. Then the attack sets in acutely, with intense vertigo, nausea and vomiting, and subjective sensations of the ground rising or external objects rotating. As a rule the patient suffers from headache, generally localized to the side principally affected by the ear disease (Mygind and Dederding). The pressure of the cerebrospinal fluid is increased in these cases. Spontaneous nystagmus is always present during the attacks and sometimes in the intervals. Nystagmus may be directed to the healthy or to the affected side, or may change from one side to the other during one and the same attack (McKenzie). The slightest movement or any attempt to look at surrounding objects greatly aggravates the symptoms. The attack is followed by prostration and a sick dizzy feeling which may last for several days.

DIAGNOSIS.—The diagnosis is made from the symptom complex described above. A careful history of the case should be taken, noting

the date of onset, the duration, frequency and severity of the attacks. In most cases examination of the ear shows no changes in the drumhead or Eustachian tubes. The hearing in the affected ear may be entirely lost but, if the deafness is only partial, it is found that the lower tone limit is raised, the upper tone limit lowered, bone conduction shortened and Rinné's test is positive. The hearing power shows considerable fluctuations, especially in favourable cases. The presence of spontaneous nystagmus should be noted. If this is present when the patient looks up, an intracranial lesion is probably present. The ability of the patient to walk in a straight line or to stand on either foot alone should be investigated. Romberg's test must be employed not only with the patient in the usual position but also with his head inclined first to one shoulder and then to the other. If the direction of the fall remains constant there is probably a lesion of the cerebellum but, if it alters with the position of the head, disease of the vestibular apparatus is indicated (Staunton Wishart). The pointing reaction and finger–nose test should be investigated and thereafter the vestibular reactions tested by rotation and cold syringing. In most cases the response to the latter test is diminished on the affected side. The condition of the digestive, urinary and circulatory systems should be inquired into and a blood film examined to exclude the bleeding diseases. Vertigo is aggravated by change of position, especially in cases of cerebral arteriosclerosis and anæmia. Ocular vertigo is rare but it is well to have the eyes tested and the optic discs examined. Choked disc probably points to a lesion in the posterior cranial fossa. Lastly, the Wassermann reaction of the blood and cerebrospinal fluid must be determined.

PROGNOSIS.—In cases due to toxin absorption the prognosis is good. Removal of the cause, e.g., extraction of teeth in cases of marked pyorrhœa, or careful dieting in patients who eat too much, usually results in ending the Ménière attacks. In the latter class of case the patients are often of the thick-necked plethoric type. In the more severe variety the prognosis as regards hearing is bad, and it is the exception for improvement to occur. The giddiness, on the other hand, tends to improve, and may entirely disappear after some months, while the nausea and vomiting continue only for a day or two. The possibility of further attacks must, however, be kept in mind, and the patient should be warned to avoid localities where an attack of giddiness would be dangerous.

TREATMENT.—Treatment of course depends on the diagnosis of the cause of the trouble. During the attacks the patient must remain in bed, and the bowels be evacuated with calomel (3 to 5 gr.) given at night, followed by a saline cathartic in the morning. Cold may be applied to the head by means of an ice-bag or Leiter's tubes. Hypodermic injections of pilocarpine are often employed, the patient being placed between blankets and surrounded by hot-water bottles. The diet should be limited, and alcohol, tea and coffee should be forbidden. In cases associated with digestive disorders, gastro-intestinal antiseptics such as salol, sodium sulphocarbolate, or hexamine may be employed. If the patient's blood-pressure is high, nitrites should be prescribed. If, on the other hand, the blood-pressure is low, tablets containing suprarenal

medulla or anterior lobe of the pituitary may be given. Anæmia, if present, should receive appropriate treatment. In cases of an allergic nature diaphoretics, diuretics and turkish baths are likely to prove of benefit : Thacker Neville advises 0·1 gramme of bulbocapnine given hypodermically, but admits it may cause headache. Allergic cases should take a diet free from salt and should limit their fluids to one pint a day Vernet recommends 5 to 20 drops of adrenalin (1–1000) twice a day by the mouth. The doses must be given progressively and the treatment interrupted every ten days. The three bromides or hydro-bromic acid or luminal are often of value in epileptiform cases. Valerian is also said to lessen the sensitiveness of the nerve apparatus.

Treatment of Tinnitus. — In cases of tinnitus, pills containing hydrarg. perchlor. $\frac{1}{60}$ gr. may be given night and morning for one month (Sacher). Bromides and luminal are also of use. If the patient's blood-pressure is high, nitrite of soda may be given. If the pressure be low, pituitary or suprarenal extracts or digitalis may help. In patients suffering from anæmia, iron and arsenic should be prescribed. Salol, sodium sulphocarbolate and other intestinal disinfectants may be of use in toxic cases. It is always advisable to search for any focus of infection, e.g., in the teeth, tonsils, nasal sinuses, gall-bladder or urino-genital organs, though it must be admitted that the ' focus of infection ' theory is somewhat exaggerated. Sometimes the wearing of an elastic bandage round the neck gives relief. Small fly-blisters—the size of a sixpenny bit—may be applied in front of, behind, and below the auricle. Many patients complain that 'the noises' are worst at night when things are quiet. Such patients may be advised to have in their rooms a clock with a very loud tick, e.g., a grandfather's clock. Lumbar puncture has been recommended by Babinski in the treatment of tinnitus. Frequent use of the galvanic current is, however, more likely to be of assistance, the positive pole being applied to the affected ear and the negative pole to the back of the neck. Radium has also been employed. It must be admitted that the treatment of tinnitus is very difficult and that failures are frequent. The patient should be encouraged to neglect his 'noises' and told not to allow them to interfere with the usefulness of his life.

In rare instances it may be justifiable to operate in non-suppurative diseases of the labyrinth. The indications for operation are unbearable tinnitus or intense giddiness, which so prostrates the patient that he is unable to work, and may even contemplate suicide. Operative inter-ference should, however, be resorted to only when all other forms of treatment have failed. The patient must be warned that the operation is not devoid of risk to life, and that the tinnitus may not disappear.

The surgeon has the choice of four operations :—

1. In cases of unbearable vertigo, Quix recommends a decompression operation over the posterior cranial fossa behind the mastoid process, as he believes that the symptoms are due to a localized increase of intra-cranial pressure in this situation (*see* also Bárány's syndrome, p. 371).

2. Reduction of the endolymphatic pressure (Portmann) by drainage of the saccus endolymphaticus by a method of approach similar to that employed in Neumann's operation on the labyrinth (p. 367)

3. Extirpation of the cochlea, the semicircular canals, and vestibule. Extirpation of the cochlea is carried out, after performing the radical mastoid operation, by removing the inner wall of the middle ear anterior to and below the facial nerve ; this exposes the modiolus, which is also taken away. Partial or total ablation of the semicircular canals and vestibule may be carried out at the same time. Successful cases have been recorded by Lake and Milligan. The danger of purulent basal meningitis must not be forgotten, especially in cases in which the cochlea is extirpated.

4. Division of the eighth nerve at its emergence from the internal acoustic meatus. The operation is similar to that devised by Harvey Cushing for tumours of the eighth nerve. Dandy made a study of forty cases in which there was no operative mortality. In twenty cases the tinnitus disappeared although a transitory vertigo occurred in many cases after the operation. He concluded that the lesion responsible for Ménière's syndrome lay in the eighth nerve itself and not in the semicircular canals.

HERPES ZOSTER AURICULARIS.

Herpes zoster affecting the ear is a rare disease. The affection may be due to exposure to cold, i.e., the so-called rheumatic neuritis. According to Ramsay Hunt, the facial nerve is a mixed nerve and has a sensory root (*pars intermedia*) and ganglion (geniculate) similar to the sensory ganglia of the spinal nerves. The sensory fibres pass in the *greater superficial petrosal* nerve to Meckel's ganglion and in the *lesser superficial petrosal* to the otic ganglion, and so to the tympanic plexus. Other fibres of general sensation emerge at the stylomastoid foramen and reach the surface of the auricle.

According to Jones and Leiner, if the lesion causing facial paralysis is limited, its site in the canal can be determined as follows. Involvement of the geniculate ganglion alone is manifested by herpetic eruption in the external auditory meatus and auricle with neuralgic pain in the ear. If above the ganglion, the sense of taste is not disturbed. If above the point of origin of the chorda tympani and below the branch to the stapedius muscle, the sense of taste in the anterior third of the tongue is affected, with excessive flow of saliva. If above the twig to the stapedius there is, in addition, severe tinnitus and hyperacusis.

Herpetic inflammations of the geniculate ganglion may be associated with peripheral facial palsy of the lower neuron type. Acoustic and vestibular complications are not infrequent, these varying from a slight diminution of hearing to a severe form, with tinnitus, deafness, nystagmus, nausea, vomiting and disturbance of equilibrium. This syndrome is due to extension of the inflammatory process to the adjacent eighth nerve and its acoustic and vestibular ganglia.

Herpes zoster auricularis may be preceded by enlargement of the lymph glands. Severe pain and the characteristic eruption on the walls of the meatus, and on the drumhead, auricle, mastoid, or pre-auricular region, are the prominent symptoms.

The disease usually runs a rapid course and heals spontaneously. Sedatives, such as phenacetin, or even hypodermic injections of morphia

or heroin, may be called for to relieve the severe pain. Massage may be employed for the treatment of the facial paralysis if this is present and persists. The value of electrical treatment in this condition has recently been called in question.

DEAFNESS DUE TO DRUGS.

It is well known that quinine and the salicylates may cause deafness, which is generally accompanied by tinnitus and sometimes by vertigo. In people who suffer from disturbance of hearing after very small doses of quinine the trouble is probably due to an idiosyncrasy of an anaphylactic nature. Wittmaack has found changes in the cells of the spiral ganglion in quinine poisoning. Ischæmia would explain these changes, as it would deprive the affected cells of nourishment. Shemeley states that mercury and aspirin may cause neuritis of the eighth nerve. In rare cases, tobacco and alcohol, if used to excess, may cause impairment of the hearing. It is accordingly advisable to prohibit their use in cases of nerve deafness in which no other cause can be ascertained, and in which excessive consumption of alcohol or tobacco is suspected or admitted. Abstinence is frequently followed by improvement in hearing.

Since salvarsan has come into general use, attention has been drawn to a possible secondary action which it may have on the eighth nerve. The cochlear branch is affected four times as often as the vestibular branch, but both portions may be involved. As Beck points out, these 'neuro-recurrences' were more frequent in the early days of salvarsan treatment—the 'era of too large doses'—and were due to a Herxheimer reaction in the eighth nerve. In order to avoid this reaction, Beck recommends preliminary treatment by mercury before administration of '606'. In some cases the changes are not limited to the eighth nerve, but may also involve other cranial nerves. Valentin has collected reports of forty-five cases of affection of the nerve which occurred after the exhibition of salvarsan. He points out that the question arises whether the deafness is due to syphilis or to the drug. In support of the former theory it has been shown by Frey that affections of the eighth nerve in the early stages of syphilis were as common before the days of salvarsan. Ehrlich also believed that the lesions of the cranial nerves after the administration of salvarsan are due to syphilitic recurrences. In many cases of neuro-recurrence in the eighth nerve the hearing had been previously affected (Beck, Felix, David); these authors accordingly recommend that the hearing should be carefully examined in every case before the administration, and Valentin advises that those whose occupation subjects them to loud noises should desist from their work for a time. As the number of neuro-recurrences is so small in comparison with the enormous number of patients who have been treated with salvarsan, and as it is by no means certain that arsenic is the cause of these lesions, we may conclude that this danger is not a contra-indication to the use of salvarsan, except possibly when there is already a non-syphilitic lesion of the ear.

Lead poisoning may give rise to nerve deafness and vertigo. Laurens has found that certain hair dyes contain a labyrinthine poison—

paraphenylenediamene—which causes headache, vertigo, deafness and tinnitus. The symptoms clear up when the dye is stopped.

NERVE DEAFNESS DUE TO INFLUENZA.

An attack of influenza is sometimes followed by tinnitus and nerve deafness, which are probably due to toxic neuritis. Isolated affection of the vestibular nerve associated with the sudden onset of vertigo, vomiting and rotatory nystagmus is said to be more common. Both parts of the eighth nerve may be involved. The treatment is that of Ménière's syndrome (p. 421). It should be noted that the symptoms may persist for weeks or even months.

ARTERIOSCLEROTIC OR SENILE DEAFNESS (PRESBYACUSIS).

In old age the hearing usually becomes impaired to some extent ; there is, as a rule, lowering of the upper tone-limit (patients often remark that they can no longer hear the birds whistling), while bone-conduction is shortened and Rinné's test positive. The watch is not heard by bone-conduction, e.g., when placed on the patient's forehead or mastoid bone, and is heard with difficulty or not at all by air-conduction. The pathology of senile nerve deafness is said to consist in degeneration of the cochlear ganglion cells and hair-cells of Corti's organ. The onset of the deafness is generally very insidious and the progress slow. A good deal of what is usually regarded as 'deafness' in old people is really due to the fact that people over 65 do not comprehend what is said, e.g., on the stage or in the cinema, as quickly as they did in childhood, youth, and middle age. Old people suffering from arteriosclerotic nerve deafness often talk in a loud, unpleasant tone—in marked contrast to the low, well-modulated voice of cases suffering from otosclerosis. Hearing trumpets are sometimes of benefit in senile deafness, but it is doubtful if they give more assistance than that obtained by placing the hand behind the auricle and holding it forward so as to collect the sound-waves.

DEAFNESS DUE TO MUMPS.

Mumps may produce labyrinthine deafness. The pathology of the condition is not known with certainty. The deafness may be due to meningitic neuro-labyrinthitis or to metastatic infection of the cochlea by way of the blood-stream. Petechial hæmorrhages in the medulla in the region of the cochlear nerve have been recorded. In a case examined by Gardiner and the writer the vestibular reactions were normal though there was complete deafness in the affected ear. In half the cases one ear only is affected. Deafness usually comes on about the fourth or fifth day of the disease, sometimes later, and does not pass off.

NERVE DEAFNESS OF DOUBTFUL ORIGIN.

It must be admitted that in many cases of nerve deafness the cause cannot be ascertained. In the young or middle-aged the Wassermann reaction of the blood and cerebrospinal fluid should always be tested, as syphilis is a common cause of nerve deafness, especially in unilateral cases.

Shambaugh points out that certain cases of otosclerosis, in which the focus of spongification affects the capsule of the cochlea in a region away from the oval window, present the signs and symptoms of nerve deafness (atypical otosclerosis) and not those of a middle ear or obstructive deafness. Such cases are rare (8 out of 113) as compared with those in which the deafness is of the middle ear type ; but, as otosclerosis is a very common disease, the atypical cases must amount in all to a considerable number. Shambaugh holds that if nerve deafness begins in early life in a member of a family in which other well-marked cases of otosclerosis are present, and if there be no other probable cause for the nerve deafness, the case should be regarded as one of otosclerosis.

German states that nerve deafness is sometimes associated with an excess of uric acid in the blood ; with a non-purin diet and anti-gouty remedies the hearing may improve.

In certain families there appears to be a tendency for the hearing power to diminish before the age at which senile deafness is usually found.
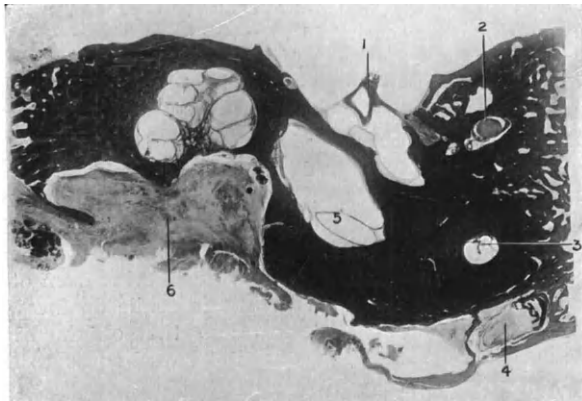
Fig. 242.—Horizontal section of right ear in a case of neurofibroma of the eighth nerve. (1) Head of stapes with stapedius ; (2) Facial nerve ; (3) Posterior canal with hæmorrhage in perilymph space ; (4) Tumour ; (5) Lower part of utricle ; (6) Dilated internal meatus with tumour. ($\times$ 3.)

TUMOURS OF THE EIGHTH NERVE.

Neurofibroma of the eighth nerve is related to general neurofibromatosis which, according to Alexis Thomson, dates from intra-uterine life. Indeed, Fehling and Ward have recorded a " familial form of acoustic tumour ". The growth starts in the internal acoustic meatus (*Fig.* 242) and is probably a mixed tumour (gliofibroma) composed of germinal tissue. The eighth nerve consists of two parts : (1) a central non-medullated portion, and (2) a peripheral medullated portion. The tumours arise from tissue-rests near the transition zone.

CHANGES IN LABYRINTH.—The first stage appears to be a fibrinous exudation (choked labyrinth), with atrophy of the cochlear ganglion and

Corti's organ (*Fig.* 243). Later the exudate becomes organized into myxomatous tissue, in which new bone formation may be seen.

SYMPTOMS.—The age of onset is usually thirty to fifty years. The clinical history may be divided into three stages :—

1. Initial or 'otological', in which the patient suffers from tinnitus, deafness, giddiness, loss of balancing and nystagmus. This stage ends with the occurrence of headache which is worst at night.

2. Intermediate or 'neurological' stage, with headache, and involvement of neighbouring nerves, producing loss of the corneal reflex, numbness over the cheek, and slight weakness of the masseter on the affected side (5th), diplopia (6th), facial paralysis (7th). Later there is dimness of vision (choked disc), dysphagia and thickness of speech, with muscular hypotonia and dysdiadokokinesia on, and tendency to fall to, the side of the lesion. In many cases the chin is turned towards the side of the tumour (Beilin). The so-called 'cerebellar seizures' or vagal attacks are a distressing feature. They may be preceded by giddiness, headache and dimness of vision. At first the patient is conscious during attacks, but later he is unconscious. The pupils are dilated, with stertorous breathing and rapid, irregular pulse. Jerkings of the head and extremities are followed by general rigidity. The attacks may be accompanied by vomiting. They are attributed by Cushing to excessive tension in the lateral lymph cistern in which the tumour lies.

Fig. 243.—Tumour of the eighth nerve. Axial section through right cochlea. (1) Dilated cochlear canal, basal coil; (2) Capsule of tumour; (3) Tumour tissue; (4) Cochlear nerve, which is compressed by tumour tissue; (5) Central canal of modiolus. Note the infiltration of the scala vestibuli and scala tympani by delicate connective tissue.

3. Terminal stage, with weakness of sphincter control, delirium, dementia, Cheyne-Stokes respiration and coma.

FUNCTIONAL EXAMINATION OF THE EARS.—*The Cochlear Apparatus.*—Except in the earliest stage there is complete deafness in the affected ear. The watch is not heard at all. Bone-conduction is shortened on the affected side. Weber's test is lateralized to the good ear ; Rinné's test is absolutely negative on the affected side. *Nerve deafness with loss of the lower tones* is diagnostic of a lesion in the nerve-stem or in the central paths. The upper tones are also lost, so that there is concentric narrowing of the hearing field.

The Vestibular Apparatus.—Spontaneous nystagmus is usually present to both sides, most marked to the homolateral side. In advanced cases

there is, as a rule, vertical nystagmus. The pointing reaction is usually normal. On Romberg's test the patient usually tends to fall to the side of the lesion. The caloric test upon the healthy side gives a normal result, or even produces an excessive reaction which may continue for five minutes. On the other hand, there is no reaction on applying the caloric test to the affected ear. There is diminution or loss of the galvanic reaction on the diseased side.

DIFFERENTIAL DIAGNOSIS.—If tumours of the eighth nerve are to be diagnosed at the early stage, otologists must *thoroughly examine all cases of unilateral nerve deafness*. Good radiograms of each temporal bone may show dilatation of the internal acoustic meatus on the affected side, in contrast with the normal meatus on the healthy side.

1. Syphilitic neurolabyrinthitis should be diagnosed by the history of syphilitic infection and the Wassermann reaction of the blood and cerebrospinal fluid.

2. Neuritis due to cold wind or to toxæmia can be eliminated by a careful history of the case and thorough physical examination. Such cases do not show complete deafness and loss of the vestibular reaction.

3. Hæmorrhage into the labyrinth in the bleeding diseases should be excluded by an examination of the blood.

4. Senile or arteriosclerotic nerve deafness is bilateral. The low tones are retained, along with the vestibular reactions.

5. Unilateral congenital deafness is rare. The vestibular reaction is present in such cases.

6. Circumscribed labyrinthitis is associated with otitis media and cholesteatoma.

7. Otosclerosis is occasionally associated with giddiness, but functional examination should clear up any difficulty.

8. Serous meningitis in the lateral cistern is as a rule associated with a history of otitis media and a well-marked pointing error, which is not usually found in acoustic tumour.

9. The condition most likely to be confounded with eighth nerve tumour is that of cerebellar cyst. In the case published by Brownlie and Wishart there was no optic neuritis, and the deafness and giddiness were preceded by diplopia ; both points in favour of cyst and against acoustic neuroma.

TREATMENT.—In early cases tumours of the eighth nerve may be operated on by the translabyrinthine route (Kutvirt had complete success in three out of four cases). Post-operative meningitis may follow this procedure so that it is probably better in all cases, and certainly in the later (intracranial) stage, to remove a large part of the occipital bone according to the method of Harvey Cushing of Boston. Even then, as Cushing admits, complete removal of the growth cannot always be expected, though the patient's life may be greatly prolonged and his condition, e.g., as regards his eyesight, is enormously improved. In favourable cases an attempt should be made not only to remove the tumour but also the capsule ; unless this is done, recurrence is certain.

HYSTERICAL DEAFNESS.

Deafness may be met with in hysteria ; it is not as a rule attended by tinnitus or giddiness. The deafness may come on without obvious cause and is subject to marked variations ; it is sometimes transferred from one side to the other. The results of the tuning-fork tests repeated on several occasions vary greatly ; this is a valuable diagnostic point. Further evidence of hysteria can generally be found, such as the presence of areas of anæsthesia, or the loss or impairment of smell or taste on the same side as the deafness. Sudden and complete recovery of hearing clinches the diagnosis of hysterical deafness.

Cases of bilateral functional deafness were frequently met with during the war as the result of shell-shock. To differentiate between bilateral organic and functional deafness, the study of the voice resonance is most helpful. In total deafness of organic origin, the patient's voice very quickly acquires the intonation characteristic of the deaf, while in functional lesions the voice remains normal. It is important to examine the cochleo-auricular, -pupillary, and -palpebral reflexes. A shrill whistle, a motor horn, or a bell with a spring hammer is suddenly sounded behind the patient who should look into the distance to avoid fixation of the pupil. If the patient hears the sound, a movement of the pinna may be noted, accompanied by contraction of the pupil and winking. Where the deafness is absolute, the voice normal, and the cochlear and vestibular reactions are also normal, the question arises whether the case is one of simulation.

Layton maintains that attention is an active process. It may be spontaneous, as in a child, or it may be voluntary, i.e., due to training. In functional deafness both spontaneous and voluntary attention are withdrawn. In the subconscious malingerer, the voluntary attention is in abeyance, and Layton compares this with the condition of a person who has to sit through a long, dull sermon. The individual does not listen, *but he does not try not to listen* ; he hears, but does not attend. In the true malingerer, on the other hand, not only is voluntary attention withdrawn, but the patient is in opposition and damps down even the spontaneous attention. The true malingerer listens intently, but tries hard not to respond. He is attempting to act the part of a deaf man, and is consequently under great mental strain, from which he desires to be relieved. Time is therefore on the side of the examiner, who should never hurry. When the patient imagines the examination is finished, he lets himself go, and may often be readily caught out.

Edwin Bramwell observes that hysterical cutaneous anæsthesia and hysterical deafness are essentially analogous. He has therefore modified Janet's test for hysterical hemi-anæsthesia so as to apply it to unilateral hysterical deafness. The patient is blindfolded and the observer, standing behind him, makes a clicking noise with the nails of his fore-finger and thumb close to the normal ear, asking the patient to say 'yes' whenever he hears the sound. When the patient clearly understands, the observer says, " Say 'yes' when you hear, and 'no' when you don't." The observer then makes the sound, using his two hands at variable

intervals sometimes close to one ear and sometimes to the other. It will be found that the patient answers 'no' if the sound is made close to the 'deaf' ear. Bramwell holds that the test does not enable one to distinguish between hysterical deafness and malingering. To arrive at a conclusion on this point one must note various extraneous data—notably the question of possible motive.

Hurst states that when hysterical deafness is associated with mutism it requires no special treatment, as hearing almost invariably returns spontaneously when speech is restored. It is advisable to let the patient know that directly he speaks he will hear his own voice and that then he will hear everything clearly. There is rarely any difficulty in curing the mutism by simple explanation and persuasion. Uncomplicated deafness is much more difficult to treat. Hypnosis is never of any use, as the patient remains deaf while hypnotized. 'Fake' operations on the ear are not invariably successful, and cannot be regarded as desirable. Most cases can be cured by explanation with persuasion and re-education. The patient is made to understand by a written statement why he is deaf, and that the original cause of his deafness long ago disappeared : as at first the deafness was organic, he could not hear, however much he listened, and consequently after a time he ceased to listen at all. He is next persuaded to listen intently, and is taught that listening is just as active a process as moving, and requires a conscious effort on his part until it becomes automatic once more. Sounds are generally heard before words can be recognized. Even when a man has apparently recovered his hearing, if caught unawares he often fails to hear.

TESTS FOR SIMULATED DEAFNESS.

There are two classes of malingerers—those who complain of (1) *unilateral*, and (2) *bilateral* deafness. Simulation of bilateral deafness requires very considerable intelligence and hardihood, and consequently its detection becomes increasingly difficult. It is only by constant observation that people who simulate bilateral deafness can be detected. Before commencing the tests for malingering in unilateral cases, it is as well to *blindfold the patient*.

1. If the hearing has been entirely lost on the right side, a tuning-fork placed upon the vertex of the skull should be heard on the left side. If the suspected malingerer is now told to place the finger in his left or hearing ear, he should hear the tuning-fork in that ear even louder than before ; but he will more probably say that he does not hear it at all, in which case, of course, the fraud is detected.

2. Place two speaking tubes, one in each ear of the patient. Two people now speak, one into each tube, on different subjects and at different rates. If the patient hears with both ears, he will confuse the voices and be unable to understand either of the people talking. If he is able to hear and follow, it will indicate that he really does not hear on one side.

3. The patient closes his good ear with a finger. The surgeon now repeats words and numbers to him, at first in a low voice and then in progressively louder and louder tones. If, when one has reached a pitch

at which he *should be able to hear the words with the sound ear even though tightly occluded,* he still states that he cannot hear, one knows at least that he is an intentional malingerer.

4. *Lombard's test* depends upon the fact that to the normal man the sound of his own voice is necessary to the proper regulation of its tone and intensity. The Bárány noise apparatus is adjusted in the patient's sound ear, and its machinery started in order to accustom him to its grating noise. He is given a book, and told to read aloud in his natural voice, and not to stop reading when the instrument is set in action. As soon as the noise begins, a man whose opposite ear is profoundly deaf will at once raise his voice and, if his unilateral deafness is absolute, may literally shout. The malingerer, on the other hand, claiming a one-sided deafness which is not real, will continue to read in an even tone or in a tone only slightly elevated.

5. *Teal's Method.*—The patient is again blindfolded, and in a friendly manner told that if he is really deaf there is no disposition to overlook it. But he is also warned that if he tries to show dishonesty he is sure to be 'tripped up'. Air-conduction is tested, and of course is negative. The Weber test is then used, and usually (though reluctantly) he hears the fork in the deaf ear. Bone-conduction over the mastoid process is next tested, and again he admits hearing the fork. The real test is now used. After saying one wants to try the last test once more, a non-vibrating fork (or lead pencil, flat end) is placed over the process to make him think he is being tested in the same manner, but at the same time a vibrating fork is brought up close to the auricle with the other hand to test the air-conduction. If he is simulating deafness he will of course answer that he hears the fork, and the fact of a normal path of air-conduction is established. If he is really deaf, he will of course not hear the vibrating fork.

DEAF-MUTISM.

A normal child learns to speak because it hears its mother and those around it speaking. The desire to imitate is inborn, and the child gradually learns to reproduce the sounds that it hears. If a child cannot hear the speech of others, it will not learn to speak itself. Even a child with normal hearing, if brought up in an isolated place in the mountains by deaf-mute parents, both of whom suffer from acquired deaf-mutism, would not learn to speak—indeed, such a case has occurred. (Note that, though in about 99 per cent of cases of mutism or dumbness the trouble is due to deafness, there are rare instances in which the patient suffers from congenital aphasia. Such a child, even when blindfolded, will carry out whispered orders, e.g., ' raise your arms' or 'open the door'.)

Deaf-mutism is a condition in which speech is absent owing to a high degree of deafness ; it may be congenital or acquired. Congenital abnormalities of the inner ear, which cause about 75 per cent of cases, have already been referred to (*see* p. 411). French observers have attributed congenital deaf-mutism to faulty development or disease of the brain but such cases are very rare.

In the acquired form of deaf-mutism, speech may at one time have been present, but has been lost owing to deafness developing at an early period of life, usually before the age of seven. Acquired deaf-mutism is the result of inflammatory conditions in the inner ear, such as : (1) labyrinthitis following meningitis, especially cerebrospinal meningitis, (2) labyrinthitis due to invasion of the internal ear in cases of middle ear suppuration caused by measles or scarlet fever (10 per cent of cases of deaf-mutism are due to scarlet fever), (3) congenital syphilis, which is responsible for about 5 per cent of cases of deaf-mutism in this country, (4) injury to both labyrinths in fracture of the cranial base.

Acquired deaf-mutism nowadays accounts for only 25 per cent of cases. Formerly the percentage was 50, but the greater care of cases of scarlatinal otitis media in fever hospitals, the more efficient treatment of syphilis and the absence of epidemic meningitis in recent years explains the change in the ratio of acquired and congenital cases.

The differential diagnosis between congenital and acquired deaf-mutism is not always an easy matter. It depends on : (1) The clinical history of the case as obtained from the parents, whose statements are often unreliable. (2) The examination of the ears by otoscopy and tuning-fork and other hearing tests. (3) Tests of the vestibular apparatus by rotation in the turning chair and the cold caloric reaction (p. 292). If the child shows the normal reactions to the vestibular tests the case is most probably one of congenital deafness in which the vestibular apparatus is usually normal. In acquired deaf-mutism due to the various forms of labyrinthitis, the vestibular reactions are almost invariably absent.

In young children the diagnosis of marked deafness requires some care, and a definite opinion should not be given until the child is a year old. To test the hearing, a loud noise is made behind the child's back, either by sounding a rattle, ringing a bell, or blowing a whistle ; if the child hears the sound he will turn his head. The cochleo-palpebral reflex may be tested even in infants by tapping a high-pitched fork (C 4096) with a key and noticing whether the child blinks. Noises which cause much vibration—for example, stamping on the floor—must not be made use of. Parents often state that they think the child is not deaf because it 'hears' a door slamming or a chair falling to the ground. These things are of course felt and not heard. When the patient is several years old the diagnosis is easily made, but in some cases the question arises whether the absence of response is due to deafness or to idiocy ; the true deaf-mute child is, however, as a rule, mentally alert and inquisitive. Complete deafness is the exception in the congenital deaf-mute ; the residue of hearing takes the form of 'islands', which are, as a rule, outside the speech area of the scale.

The drum-membrane in congenital cases is not infrequently normal, but in some there is retraction of the membrane due to Eustachian obstruction. In the acquired cases, the appearances of the membrane are those of the disease which causes the deafness.

TREATMENT.—Little can be hoped for from local treatment, but any existing ear disease should receive attention. The education of the deaf child is of the greatest importance. The chief objects are to make it possible for him to become self-supporting in adult life and to enable him to communicate with his fellows. Education may be by the oral (lip-reading) or by the manual (finger-spelling) method, or by combining the two. The former is the ideal method for, if successful, it enables the child to have intercourse by speech with hearing people and to lip-read what they say. The child taught by the manual method can only communicate in writing with those who cannot use the manual alphabet. The oral method is not, however, universally applicable ; it is out of the question in the mentally defective (15 per cent), and is unsuccessful in 10 to 30 per cent of average deaf-mutes ; moreover, deaf-mutes, who have never heard, speak in an unnatural manner which is very difficult to understand. The oral system is more suitable for the 'semi-deaf' who have some remains of hearing, and for 'semi-mutes' who became deaf after they had learned to talk, and therefore still have some remains of speech (20 to 30 per cent). The oral system of teaching takes at least eight years, and necessitates classes of not more than twelve. Education should begin at 3 or 4 years and continue till the patient is 18 years of age. During the later years the boy or girl also learns a suitable trade, such as boot-making, tailoring, etc.

When a child has been ascertained to be too deaf to pick up speech in the ordinary way, much may be done by special education if a certain amount of hearing exists. Wright points out that the force with which sound-waves impress the hearing mechanism varies inversely as the square of the distance from the source of sound to the ear. A word spoken to a child a yard from the ear makes a certain impression. The same word spoken one inch from the ear will make 1296 times as much impression. At least one-third of all children at schools for the deaf and dumb have some residue of hearing power. Every case should be treated on the supposition that there may be some remaining power of sound perception until long experiment has proved it otherwise. If a mother will talk to her deaf boy while facing a big mirror and holding her mouth very near his ear, he can then see her lips and also hear her voice. Great patience and constant repetition are necessary.

Minor Degrees of Deafness in Children.—Statistics show that 5 to 20 per cent of all pupils in the public elementary schools have more or less defective hearing. The hearing should be tested by the gramophone-audiometer (p. 280). Even a slight degree of deafness may cause the child to do its work under considerable nerve strain. It has been found that many children " at the bottom of the class " suffer from deafness of greater or lesser degree. Special schools with small classes instructed by trained teachers are urgently required for 'hard-of-hearing' children. The standard in Berlin for the admission of a child to the 'hard-of-hearing' school is perception of the conversation voice at a distance of less than eight feet. At the present time, arrangements are made in this country (with a few praiseworthy exceptions) only for children with normal hearing and for deaf-mutes.

AIDS TO HEARING.

When deafness in an adult becomes so marked that ordinary conversation cannot be heard, some aid to hearing is required.

Lip- or Speech-reading. — Young adult patients with progressive deafness, e.g., otosclerosis, should be told to take up lip-reading. In many of the larger towns classes on this subject are given by teachers who are expert in the training of the deaf. The partially deaf adult should begin to study lip-reading before his defect in hearing has become noticeable. From three to six months—in exceptional cases one year—are required for the mastery of lip-reading. Shy patients, who do not care to stare at the faces of their friends or acquaintances, make poor lip-readers. Older patients as a rule fail to acquire the art.

Artificial Aids to Hearing.—These are divided into two classes— mechanical and electrical. Mechanical aids may take the form of tubes, trumpets, 'auricles', or resonators. They are to be preferred to electrical apparatus, as the tone of the speaker's voice is more natural, the initial expense is less, there is no cost of maintenance and the instruments give no trouble. Mechanical aids are certainly most suitable in cases of nerve deafness, e.g., in old people. A speaking-tube is the most effective for ordinary conversation ; one end is placed in the patient's ear, while the speaker holds the other to his mouth. The speaking-tube is of no value in churches, theatres, or other public places. In order to hear at a distance a bell-shaped instrument is required, but its size is a great disadvantage, as it attracts attention to the patient's disability. In many cases the patient hears just as well if he places his cupped hand behind his ear. Artificial celluloid 'auricles', worn beneath the hair, are often of use in the case of female patients ; the sound is conducted to the ear by celluloid tubes which are easily hidden by the hair. The present method of hair-dressing is, however, seldom suitable for 'auricles'. In women with well-preserved bone-conduction the fan-shaped audiphone is sometimes of service ; when in use, the edge of the fan is held against the teeth. Artificial drumheads, of which the simplest and best is a very small pellet of cotton-wool, soaked in liquid paraffin, may be employed in cases of dry perforation of the drum-membrane exposing the region of the oval window. A skilful patient soon learns to insert and remove the pellet himself with the aid of aural forceps.

Electrical aids consist, as a rule, of three parts—a receiver, a battery and a transmitter, connected by cords. This micro-telephone has been much advocated as an aid to hearing, its use being suggested by the fact that deaf persons often hear the telephone well. In many cases, however, it is not of much service, and causes the patient great annoyance by producing a considerable amount of secondary noise. Instruments with thermionic valves are useful in severe cases of middle ear deafness but are heavy and expensive. Speaking generally, it is impossible to say without trial which aid to hearing, if any, will help a particular patient : it is therefore imperative for the patient himself to go with an intelligent friend to the makers, and test various appliances before

deciding. The friend should be provided with a book or newspaper, from which he reads aloud, so that any improvement due to the various instruments may be ascertained. Hitherto most otologists have made little or no attempt to prescribe artificial aids to hearing on scientific lines similar to those on which ophthalmologists order spectacles. In these circumstances in the case of the more expensive instruments at any rate the patient should insist on a two or three weeks' trial of the apparatus at his own home. This is allowed by most instrument makers if a comparatively small deposit is paid. A great many of the so-called 'aids to hearing' can only be described as 'humbug' apparatus (Mailand). These instruments are all small (patients desire this), but of little use and relatively very expensive.

During recent years attempts have been made to re-educate deaf people by means of sounds corresponding to the registers of the human voice. The best-known instruments employed for this purpose are the Electrophonoïde of Zünd-Burguet and the Kinesiphone of Maurice.

APPENDIX

FORMULÆ.

NOTE.—*The quantities given in the metric system are not to be taken as exact equivalents, but only as convenient proportions.*

THE NOSE AND PARANASAL SINUSES.

THE NASAL VESTIBULE.

℞ Acidi Salicylici
    Sulphuris Præcipitati   -   -   -   āā *gr.* 5j   0·3
    Paraffinum Molle Album   -   -   -   ad ℥j   ad grm. 30·0
                  - *Sig.*—The ointment as directed.
    Use.—In dermatitis of nasal vestibule.

℞ Ung. Hydrargyri Nitratis   .
    Paraffini Mollis Flavi   -   -   -   āā ℥j   grm. 4·0
                  . *Sig.*—The ointment for the nose.
    Use.—In dermatitis of nasal vestibule.

THE NASAL CAVITIES.

℞ Menthol   -   -   -   -   -   ℨij   grm. 8·0
    Sig.—Put a pint of boiling water in a two-pint jug, and after five
        minutes add a pinch of the crystals, and inhale at intervals.
    Use.—As an inhalation in acute catarrh of the nasal cavities and
        sinuses.

℞ Menthol   -   -   -   -   -   gr. 18   grm. 1·2
    Spirit. Rectificati   -   -   -   -   ℨiv   c.c. 15·0
          Sig.—Fifteen to thirty drops in hot water to be inhaled.
    Use.—As inhalation in acute catarrh of the nasal sinuses.

℞ Menthol   } 10%   -   -   ℥j   c.c. 30·0
    Paraffini Liquidi B.P.   }
                  Sig.—In an atomizer at intervals.
    Use.—In nasal catarrh.

℞ Menthol   -   -   -   .   .   gr. 5   grm. 0·3
    Camphoræ   -   -   -   .   .   gr. 2   grm. 0·2
    Ol. Cinnamomi Veri   -   -   -   ℳ 2   c.c. 0·2
    Paraffinum Liquidum B.P.   -   -   ad ℥j   ad c.c. 30·0
          Sig.—To be used with a nasal atomizer after the nasal cavities
              have been cleansed by means of the alkaline nose wash.
    Use.—As a spray in nasal catarrh.

℞ Ephedrinæ Hydrochloridi   -   -   gr. 5   grm. 0·3
    Menthol
    Camphoræ   -   -   -   gr. 10   grm. 0·6
    Paraffini Liquidi   -   -   -   -   ℥j   c.c. 30·0
              Sig.—In an atomizer occasionally.

℞ Resorcini - - • - - gr. 5 grm. 0·3
   Ol. Olivæ - • - - - ad ℥j ad c.c. 30·0
           Sig.—Drop in the solution with a pipette.
      Use.—For nasal catarrh in infants.

℞ Sodii Bicarbonatis
   Sodii Biboratis - - - - āā ℥j grm. 30·0
   Sodii Chloridi - - - - ℥ij grm. 60·0
              M. ft. pulv.
   Sig.—Dissolve one teaspoonful in a half-pint of water. Use as directed.
      Use.—As nose wash.

℞ Ung. Hydrargyri Nitratis Fortis B.P. - ℨj grm. 4·0
   Paraffinum Molle Flavum - - - ad ℥j ad grm. 30·0
      Sig.—Apply on cotton-wool mops or on a strip of sterile gauze.
      Use.—Mild antiseptic for the nasal cavities.

       DIRECTIONS FOR CLEANSING THE NOSE IN CASES OF OZÆNA.

1. Plug each nostril completely with cotton-wool for half an hour on rising.
2. Remove the plugs.
3. Syringe through each nostril alternately with the tepid salt water.
4. Breathe rapidly through mouth while syringing.
5. After syringing blow down each nostril alternately.
6. Repeat at bedtime.
    Requirements.—Cotton-wool. Higginson's syringe. Two pints of tepid water containing two teaspoonfuls of table salt.

℞ Glucosi Anhydrosi Puri - - - ℨiv grm. 15·0
   Glycerini - - - - - ℥iss c.c. 45·0
   Sig.—A strip of self-edge gauze, one inch wide, to be soaked in the above solution, and packed into each nasal cavity.
      Use.—In ozæna.

℞ Calcii Chloridi *vel* Calcii Lactatis - - ℨiij grm. 12·0
   Aq. Menthæ Piperitæ - - - ad ℥vj ad c.c. 180·0
      Sig.—A tablespoonful (c.c. 16) thrice daily after meals.
      Use.—In asthma.

℞ Caffeinæ Valerianatis - - - gr. 2 grm. 0·12
   Theobrominæ et Sodii Salicylatis - - gr. 5 grm. 0·30
              Ft. cachet, mitte tales 12.
   Sig.—One cachet morning and evening.
      Use.—In asthma.

℞ Acidi Arseniosi - - - gr. $\frac{1}{64}$ grm. 0·001
   Extracti Belladonnæ Sicci - - - gr. $\frac{1}{4}$ grm. 0·016
   Strychninæ Hydrochloridi - - - gr. $\frac{1}{64}$ grm. 0·001
   Excipientis - - - - - q.s. q.s.
           Ft. pil., mitte tales 12.
      Sig.—One pill thrice daily after meals.
      Use.—In nasal neuroses.

℞ Pulv. Peptoni Bovini Siccati - - gr. 4 grm. 0·25
             Ft. cachet, mitte tales 12.
      Sig.—One cachet fifteen minutes before lunch and dinner.
      Use.—In rhinorrhœa.

THE NOSE AND PARANASAL SINUSES—*contd.*

(1) ℞ Camphoris
      Menthol -   ·   -   -   āā gr. 15   grm. 1·0
      Tinct. Iodi -   -   ·   -   ʒj   c.c. 4·0
      Spirit. Rectificati   -   -   -   ʒij   c.c. 8·0
      Glycerinum   ·   -   -   ad ℥j   ad c.c. 30·0

(2) ℞ Acidi Carbolici -   -   -   -   ʒj   grm. 4·0
      Tinct. Iodi cum Potassii Iodido (ad sat.)   ʒij   c.c. 8·0
      Glycerini -   -   -   -   ʒiv   c.c. 16·0
      Sig.—Dip the post-nasal brush first in No. 1 and then in No. 2 and
                    apply as directed.
      Use.—Paint for nasopharynx in chronic catarrh.

℞ Acidi Borici -   -   -   -   gr. 5   grm. 0·3
   Menthol -   -   -   -   gr. 1   grm. 0·1
   Ol. Gaultheriæ   -   -   -   ℥1   c.c. 0·1
   Adipis Lanæ Hydrosi   -   -   ʒj   grm. 4·0
   Paraffini Mollis Albi -   -   ·   ʒij   grm. 8·0
                      Ft. ung.
      Sig.—Apply to the nostrils on cotton-wool, twice daily.
      Use.—Useful after intranasal operation.

℞ Cocainæ Hydrochloridi   }
   Aq. Destillatæ Sterilis   } 90 % -   -   ʒss   c.c. 2·0
             Sig.—One drop on a dressed nasal probe.
      Use.—One-minute trunk anæsthesia for intranasal operations.

℞ Acidi Carbolici   -   }
   Paraffini Liquidi B.P.   } ¼%   -   ℥iv   c.c. 120·0
      Sig.—To be applied once daily to nasal cavities, in a syringe.
      Use.—After intranasal operations.

THE PHARYNX.

℞ Sodii Bicarbonatis -   -   -   -   gr. 60   grm. 4·0
   Liq. Thymol Co. B.P.C.
   Glycerini -   -   -   -   āā ℥ij   c.c. 60·0
         Sig.—Mouth wash and gargle : a tablespoonful in a
                   teacupful of warm water.
      Use.—In acute tonsillitis and after tonsillectomy.

℞ Resorcini -   -   -   -   -   gr. 5   grm. 0·3
   Glycerini Boracis -   -   -   ʒj   c.c. 30·0
               Sig.—Throat paint.
      Use.—In subacute and chronic tonsillitis, prior to operation.

℞ Ferri et Ammonii Citratis -   -   ʒij   grm. 8·0
   Liq. Arsenicalis -   -   -   ℥36   c.c. 2·0
   Tinct. Nucis Vomicæ -   -   ʒj   c.c. 4·0
   Inf. Calumbæ -   -   -   ad ℥vj ad c.c. 180·0
        Sig.—One tablespoonful (16 c.c.) in water after food.
      Use.—Tonic in convalescence after tonsillitis, etc.

℞ Liq. Arsenicalis
   Vin. Ipecacuanhæ -   -   ·   -   āā ʒj   c.c. 4·0
   Spirit. Rectificati -   -   -   ʒij   c.c. 8·0
         Sig.—*Poison.* Paint on affected area with a brush.
      Use.—Local application for Vincent's angina.

℞ Sodii Perboratis -   -   -   ʒij   grm. 8·0
        Sig.—Dissolve in a glass of water to make the gargle.
      Use.—As a gargle in Vincent's angina.

℞ Iodi - - - - - - gr. 6 grm. 0·5
Potassii Iodidi - - - - gr. 25 grm. 1·6
Ol. Menthæ Piperitæ - - - gtt. 10 c.c. 0·5
Glycerinum - - - - - ad ℥j ad c.c. 30·0
    Sig.—Apply with a brush to the back of the throat
        morning and night.
   Use.—In chronic inflammation of the tonsils.

Phenol Sodique.—

℞ Acidi Carbolici
Sodii Sulphocarbolatis - - - āā gr. 36 grm. 2·5
Sodii Bicarbonatis - - - - gr. 50 grm. 3·5
Glycerini - - - - - ℨvj c.c. 24·0
Liquor. Carmini B.P.C. - - - ♏5 c.c. 0·5
Aq. Aurantii Flor. - - - - ad ℥iv ad c.c. 120·0
    Sig.—Two teaspoonfuls (8 c.c.) in a wineglassful of water
        to make the gargle.
   Use.—As a gargle after tonsil operations.

℞ Thymol - - - - - gr. ¹⁄₃₂ grm. 0·002
Hydrargyri Subchloridi - - - gr. ¼ grm. 0·01
Glycogelatini - - - - - q.s. q.s.
       Ft. pastil.
     Sig.—The pastille.
   Use.—After tonsillectomy.

℞ Menthol - - - - - gr. 6 grm. 0·35
Acidi Benzoici - - - - gr. 3 grm. 0·2
Paraffinum Liquidum - - - ad ℥j ad c.c. 30·0
    Sig.—The oily solution to be used in spray.
   Use.—In pharyngitis.

℞ Vin. Antimonialis
Vin. Ipecacuanhæ - - - - āā ℨij c.c. 8·0
Syr. Aurantii - - - - ℨiv c.c. 16·0
Aq. Cinnamomi - - - - ad ℥vj ad c.c. 180·0
    Sig.—One tablespoonful (16 c.c.) in water every three hours.
   Use.—In early stage of acute pharyngitis.

℞ Liq. Strychninæ Hydrochloridi - - ℨj c.c. 3·5
Liq. Ferri Perchloridi - - - ℨij c.c. 7·0
Liq. Hydrargyri Perchloridi - - - ℨiij c.c. 10·5
Glycerini - - - - - ℨiv c.c. 15·0
Aquam Destillatam - - - - ad ℥vj ad c.c. 180·0
    Sig.—One tablespoonful (16 c.c.) in water every four hours.
   Use.—In acute streptococcal pharyngitis.

Mandl's Paint.—

℞ Iodi - - - - - - gr. 6 grm. 0·5
Potassii Iodidi - - - - gr. 20 grm. 1·5
Ol. Menthæ Piperitæ - - - ♏5 c.c. 0·25
Glycerini - - - - - ℥j c.c. 30·0
    Sig.—Mandl's paint : use as directed.
   Use.—In chronic pharyngitis, etc.

THE PHARYNX—*contd.*

R Sodii Bicarbonatis - - - - ʒj grm. 4·0
Tinct. Rhei Co. - - - - ʒvj c.c. 24·0
Ammonii Carbonatis - - - - gr. 24 grm. 1·5
Aq. Menthæ Piperitæ - - - ad ℥vj ad c.c. 180·0
Sig.—One teaspoonful (4 c.c.) in water three times a day,
half an hour before food.
Use.—In chronic pharyngitis of dyspeptic origin.

R Pulv. Orthoformi
Pulv. Resorcini - - - - āā p. æq.
Sig.—Powder for insufflation.
Use.—To relieve pain of raw surface in the pharynx. Applied by
means of Leduc's glass tube or ordinary insufflator.

THE LARYNX.

R Tinct. Benzoin. Co. - - - - ℥i c.c. 30
Sig.—One or two teaspoonfuls in a jug of hot water (170° F.)
as an inhalation.
Use.—In acute laryngitis.

R Diamorphinæ (Heroin) Hydrochloridi - gr. $\frac{1}{12}$ grm. 0·005
Pulv. Sacchari Lactis - - - gr. 8 grm. 0·5
Ft. pulv., mitte 12.
Sig.—One thrice daily or as required.
Use.—In acute laryngitis (post-influenzal).

Or, as alternative :—
R Diamorphinæ (Heroin) Hydrochloridi - gr. 1 grm. 0·06
Spirit. Chloroformi - - - - ʒj c.c. 4·0
Tinct. Cocci - - - - ♏25 c.c. 1·5
Syr. Aurantii - - - - ʒj c.c. 30·0
Aq. Aurantii Floris - - - - ad ℥iss ad c.c. 50
Sig.—Twenty to sixty drops a day.
Use.—In acute laryngitis (post-influenzal) with cough.

R Sodii Bicarbonatis - - - - gr. 30 grm. 2·0
Aq. Destillatæ - - - - ℥iv c.c. 120·0
Sig.—Use at a temperature of 120° F. as a laryngeal spray.
Use.—In laryngitis.

R Argenti Nitratis } 2 to 5 % - ʒii c.c. 8·0
Aq. Destillatæ }
Sig.—Apply as directed.
Use.—In subacute laryngitis.

R Olci Pini Sylvestris - - - - ♏36 c.c. 2·0
Magnesii Carbonatis Levis - - - gr. 20 grm. 1·5
Aq. Destillatæ - - - ℥i c.c. 30
Sig.—A teaspoonful in a jug of hot water (170° F.)
as an inhalation.
Use.—In subacute and chronic laryngitis.

R Pulv. Aluminis Purificati - - - ʒss grm. 2·0
Pulv. Sacchari Lactis - - - ad ʒv ad grm. 20·0
M. ft. pulv.
Sig.—Use as insufflation.
Use.—Astringent in chronic laryngitis with excessive secretion.

℞ Ammonii Sulpho-ichthyolatis   -   -   ℨj   grm. 4·0
   Glycerini   -   -   -   -   -   ℨiv   c.c. 20·0
   Ol. Menthæ Piperitæ   -   -   -   ♏5   c.c. 0·5
           Sig.—Apply as directed.

    Use.—In chronic laryngitis.

℞ Acidi Lactici B.P.
           Sig.—Apply as directed

    Use.—In lupus and tuberculous ulceration.

℞ Menthol | 10 to 15 %
   Paraffini Liquidi B.P. |
        Sig.—Use with nebulizer or intratracheal syringe

    Use.—In tuberculous disease of larynx.

℞ Guaiacol   -   -   -   ·   -   ℨij   c.c. 8·0
   Chloroformi -   -   -   ⁄   -   ℨj   c.c. 4·0
   Menthol   -   ·   -   ⁄   -   gr. 15   grm. 1·0
   Ol. Pini Sylvestris   -   -   -   ♏15   c.c. 1·0
   Terebeni   -   -   -   -   ℨj   c.c. 4·0
   Spirit. Rectificatum -   -   -   ad ℥j   ad c.c. 30·0
       Sig.—For inhalation by means of a Burney-Yeo inhaler.

    Use.—In tuberculous disease of larynx.

℞ Liq. Formaldehydi B.P.   -   -   -   ♏12   c.c. 0·75
   Chloroformi -   -   -   -   -   ℨj   c.c. 4·00
   Menthol   -   -   -   -   -   gr. 10   grm. 0·6
   Ol. Pini Sylvestris   -   -   -   ♏10   c.c. 0·75
   Spirit. Rectificatum -   -   -   ad ℥j   ad c.c. 30·0
       Sig.—For inhalation by means of a Burney-Yeo inhaler.

    Use.—In tuberculous disease of larynx.

℞ Pulv. Orthoformi B. -   -   -   -   ℨij   grm. 8·0
          Sig.—Use as insufflation.

    Use.—In dysphagia of tuberculous ulceration, etc.

THE EAR.

DERMATITIS OF AURICLE AND EXTERNAL ACOUSTIC MEATUS.

Ung. Zinci et Ichthammol.—
℞ Ichthammol   -   -   ·   -   ℨj   grm. 4·0
   Ung. Zinci Oxidi B.P.   -   ·   -   ℨiij   grm. 12·0
   Paraffinum Molle Flavum   -   -   ad ℥j   ad grm. 30·0
       Sig.—Local application on cotton mops or gauze packing.

    Use.—In acute auricular eczema with denuded surface or consider-
    able inflammatory reaction.

℞ Acidi Salicylici
   Sulphuris Præcipitatæ   -   -   - āā gr. 10   grm. 0·6
   Paraffinum Molle Flavum   -   -   ad ℥j   ad grm. 30·0
        Sig.—The ointment to be applied on a strip of gauze
                  or on cotton mops.

    Use.—In cases of dry otitis externa.

Ung. Hydrargyri Oxidi Rubri (fragrans).—
℞ Ung. Hydrargyri Oxidi Rubri   -   -   ℨij   grm. 8·0
   Ung. Aquæ Rosæ   -   -   -   -   ad ℥j   ad grm. 30·0
       Sig.—The ointment to be applied on a strip of gauze
                or on cotton mops.

    Use.—In chronic eczema of meatus or auricle.

<center>THE EAR—<i>contd.</i></center>

Solutio Argenti Nitratis.—
℞   Argenti Nitratis -   -   -   gr. 10 to 20   grm. 0·6 to 1·25
     Aq. Destillatam -   -   -   ad ℥j   ad c.c. 30·0
        Sig.—Apply locally by means of cotton-wool which has been
                 repeatedly washed with distilled water.
      Use.—In cases of otitis externa.

℞   Acidi Borici -   -   -   -   -   gr. 15   grm. 1·0
     Spirit. Rectificatum -   -   -   -   ad ℥j   ad c.c. 30·0
           Sig.—The ear drops : use as directed.
      Use.—In cases of otitis externa.

<center>BOILS IN THE EAR.</center>

℞   Ichthamol in Glycerine, 10%   -   -   ℥ij   c.c. 60·0
      Sig.—To be packed into external acoustic meatus on a narrow strip
                of self-edge gauze.

     Sol. Aluminii Acetatis, 8% -   -   -   ℥iv   c.c. 120·0
      Sig.—To be packed into external acoustic meatus on a narrow strip
                of self-edge gauze.

<center>TREATMENT OF EARACHE.</center>

℞   Acidi Carbolici   -   -   -   -   gr. 6   grm. 0·5
     Glycerini   -   -   -   -   -   ℨij   c.c. 10·0
        Sig.—Ten drops to be put into the ear from a warmed teaspoon
               when pain is severe, or as directed.
      Use.—Sedative.

℞   Acidi Carbolici
     Menthol   -   -   -   -   āā gr. 15   grm. 1·0
     Glycerinum -   -   -   -   ad ℨiv   ad c.c. 15·0
             Sig.—The ear drops as directed.
      Use.—Sedative in cases of otalgia.

<center>MEDICATED EAR DROPS IN CASES OF MIDDLE-EAR SUPPURATION.</center>

℞   Sol. Hydrogenii Peroxidi (10 vols.)   -   ℥j   c.c. 30·0
      Sig.—Ten drops to be instilled and left for two or three minutes
                before syringing.

℞   Acidi Borici -   -   -   -   -   gr. 10   grm. 0·6
     Spirit. Rectificati   -   -   -   ℥j   c.c. 30·0
        Sig.—Ten drops to be instilled after the meatus has been syringed
               and then dried out with cotton mops.

℞   Sol. Hydrogenii Peroxidi (10 vols.)
     Spirit. Rectificati   -   -   -   āā ℥ss   c.c. 15·0
        Sig.—Dry out the meatus with cotton mops and then instil ten
               drops of the solution.

Guttæ Acidi Salicylici.—
℞   Acidi Salicylici   -   -   -   -   gr. 10   grm. 0·6
     Spirit. Rectificati   -   -   -   ℥j   c.c. 30·0
          Sig.—Instil ten to twenty drops after syringing and drying
                  out the meatus.
      Use.—In cases of cholesteatoma.

Calot's Solution.—

R   Paraffini Liquidi (B.P.)   -   -   -   ℥ij + ℨiss   grm. 70
    Sterilize by boiling for 30 minutes ; allow to cool, and add in order—
    Creasoti   -   -   -   -   -   ♏︎75   grm. 5
    Guaiacolis   -   -   -   -   ♏︎15   grm. 1
    Iodoformi (sterile)   -   -   -   -   gr. 150   grm. 10
    Ætheris   ·   -   -   -   -   ℥j   grm. 30

      Sig.—After the daily cleansing of the external meatus, 10 drops
        of Calot's solution are instilled and forced into the deeper parts
        of the middle ear by tragal pressure.

WAX IN THE EXTERNAL MEATUS.

R   Sodii Bicarbonatis   -   -   -   -   gr. 10   grm. 0·6
    Aquam   -   -   -   -   -   ad ℥j   ad c.c. 30·0

      Use.—Ear drops to be used before syringing the ear for wax.

PARACENTESIS TYMPANI : INCISION OF THE DRUMHEAD.

Blegvad's Drops.—

R   Cocainæ Hydrochloridi
    Acidi Salicylici   -   -   -   -   āā ℥j   grm. 4·0
    Spirit. Rectificati   -   -   -   -   ℥ij   c.c. 8·0

      Sig.—The solution to be applied on small pledgets of cotton-wool
        packed against the drumhead for twenty minutes before
                 paracentesis.

Bonain's Mixture.—

R   Menthol   )
    Acidi Carbolici   ⎰   -   -   -   āā p. æq.
    Cocainæ Hydrochloridi   )

      Sig.—To be applied on small pledgets of cotton-wool packed against
                the drumhead.

LOTIONS FOR SYRINGING THE EAR IN ACUTE OR CHRONIC MIDDLE-EAR SUPPURATION.

R   Sol. Acidi Borici Sterilis (ad saturandum) ·   q.s.
          Sig.—For syringing the ear : use lukewarm.

      Use.—In cases of acute or chronic suppurative otitis media.

R   Lysol   -   -   -   -   -   ℥iv   c.c. 120·0
      Sig.—Put half a teaspoonful of lysol in a pint of lukewarm sterile
              water and syringe ear.

      Use.—In chronic suppuration.

Lotio Hydrargyri Perchloridi.—

R   Hydrargyri Perchloridi   -   -   -   gr. ⅙   grm. 0·01
    Aq. Destillatam   -   -   -   -   ad ℥j   ad c.c. 30·0

      Sig.—To be mixed with an equal quantity of sterile warm water to
        make a lotion for syringing the ear ; a glass syringe
             should be used.

      Use.—Antiseptic.

AURAL GRANULATIONS.

R   Acidi Chromici   -   -   -   -   q.s.
        Sig.—Use as crystals fused on a silver probe.

R   Acidi Trichloracetici -   •   -   -   q.s.
      Sig.—To be applied by means of a small pledget of cotton-wool
                 on a probe.

THE EAR— *contd.*

INSUFFLATIONS IN CASES OF MIDDLE-EAR SUPPURATION WITH LARGE PERFORATION.

Insufflatio Iodoformi.—

℞ Pulv. Iodoformi   - · - -   ℨj   grm. 4·0

    Pulv. Acidi Borici - · - -   ℨiij   grm. 12·0

                  M.

    Sig.—A little of the powder to be blown on to the inner tympanic wall with an aural insufflator.

    Use.—Antiseptic.

Insufflatio Acidi Borici.—

℞ Pulv. Acidi Borici - - · ·   q.s.

    Sig.—A little of the powder to be blown on to the tympanic wall with an aural insufflator.

    Use.—Mild antiseptic.

℞ Iodi Resublimati   - - - -   gr. 3·6   grm. 0·216

    Pulv. Acidi Borici   - - - -   ad. ℨj   grm. 0·30

    Sig.—Iodine 0·75 per cent in boric powder; use in a powder blower as directed.

    Rub down the iodine with a few drops of spirit. vini rect. until solution is effected, and gradually incorporate the finely powdered boric acid. The preparation should be freshly prepared and kept in a well-closed container to avoid, as far as possible, loss of iodine by volatilization.

CHRONIC SUPPURATION IN THE EUSTACHIAN TUBE (TUBORRHŒA).

℞ Argyrol   }   25 to 50 %   -   ℨij   c.c. 8·0

    Aq. Destillatæ Sterilis }

    Sig.—The solution may be injected through the Eustachian catheter with the aid of a Pravaz syringe and Politzer bag, or it may be instilled into the external acoustic meatus and then driven into the tube by using the Politzer bag as in testing for labyrinth fistula.

Guttæ Protargol.—

℞ Protargol   - - - - -   gr. 24   grm. 1·5

    Aq. Destillatæ Sterilis   - - -   ℨiv   c.c. 15·0

                 Sig.—As above.

FOR LOCAL ANÆSTHESIA PRELIMINARY TO OSSICULECTOMY, REMOVAL OF AN AURAL POLYPUS, OR THE SCHWARTZE MASTOID OPERATION.

℞ Sol. Novocainæ Hydrochloridi (1 %)   -   ℳ 60   c.c. 3·5

    Liq. Adrenalini Hydrochloridi   - -   ℳ 4   c.c. 0·25

    Sol. Sodii Chloridi (0·75 %) - - -   ad ℨiv   ad c.c. 15·0

    Sig.—For infiltration anæsthesia by Neumann's method.   (*See* p. 352.)

EAR DROPS FOR USE AFTER THE RADICAL MASTOID OPERATION WHEN NO SKIN GRAFT HAS BEEN APPLIED.

℞ 'Scarlet Red'   - - - -   gr. 20   grm. 1·25

    Spirit. Rectificati   - - - -   ℨj   c.c. 30·0

    Sig.—Twenty drops to be instilled into the operation cavity.

    Use.—To promote epithelialization.

℞ 'Brilliant Green'   }   1–1000

    Sol. Allantoin (0·25 %) }

    Sig.—Twenty drops to be instilled into the operation cavity after cleansing.

    Use.—To promote epithelialization.

TINNITUS AND VERTIGO.

Mistura Potassii Bromidi.—
R   Potassii Bromidi -   -   -   ℨij to ℥j   grm. 8·0 to 32·0
     Spirit. Ammoniæ Aromatici -   -   ℨiv   c.c. 15·0
     Aq. Camphoræ   -   -   ·   ad ℥vi   ad c.c. 180·0
         Sig.—A tablespoonful (16 c.c.) to be taken largely diluted
                     with water as ordered.
     Use.—Sedative.

Mistura Acidi Hydrobromici.—
R   Acidi Hydrobromici Diluti -   -   ℨvj to ℨxij   c.c. 25·0 to 50·0
     Aq. Chloroformi   -   -   -   ad ℥vj   ad c.c. 180·0
         Sig.—A dessertspoonful to a tablespoonful (8 to 16 c.c.) to be
         taken thrice daily after meals, freely diluted with water.
     Use.—Sedative—in cases of tinnitus.

Mistura Acidi Hydrobromici cum Quininâ.—
R   Acidi Hydrobromici Diluti -   -   -   ℨiij   c.c. 12·0
     Quininæ Sulphatis   -   -   -   -   gr. 6   grm. 0·4
     Spirit. Chloroformi -   -   -   -   ℨj   c.c. 4·0
     Aquam   -   -   -   -   -   ad ℥vj   ad c.c. 180·0
         Sig.—A dessertspoonful to a tablespoonful (8 to 16 c.c.)
                thrice daily after meals.
     Use.—In cases of vertigo.

R   Potassii Iodidi   -   -   ·   -   gr. 60   grm. 4·0
     Potassii Bromidi   -   -   -   -   gr. 120   grm. 8·0
     Tinct. Jaborandi   -   -   -   -   ♏180   c.c. 12·0
     Syr. Glycerophosphatis   -   -   ·   ℥iij   c.c. 100·0
     Aq. Aurantii Floris -   -   -   -   ad ℥vj   ad c.c. 180·0
         Sig.—A tablespoonful (16 c.c.) thrice daily after meals.
     Use.—In cases of tinnitus and giddiness.

R   Sodii Nitritis -   -   -   -   gr. 24 to 48   grm. 1·5 to 3·0
     Aq. Destillatam   -   -   -   ad ℥iij   ad c.c. 90·0
         Sig.—A teaspoonful (4 c.c.) for a dose.
     Use.—In cases of tinnitus and giddiness with high blood-pressure.

R   Salol -   -   -   -   -   gr. 5 to 10   grm. 0·3 to 0·6
           Ft. pulv., mitte tales 12.
         Sig.—One powder thrice daily.
     Use.—In cases of tinnitus and giddiness associated with intestinal
         toxæmia.

R   Sodii Sulphocarbolatis   -   -   -   ℨij   grm. 8·0
     Aq Destillatam   -   -   -   -   ad ℥vj   ad c.c. 180·0
         Sig.—A tablespoonful for a dose.
     Use.—In cases of tinnitus and giddiness associated with intestinal
         toxæmia.

R   Hydrargyri Perchloridi   -   -   -   gr. $\frac{1}{60}$ grm. 0·001
     Sacchari Lactis   -   -   -   gr. 1   grm. 0·064
     Excipientis   -   -   -   -   -q.s. ad gr. 3   ad grm. 0·2
           Ft. pil., mitte tales 60.
         Sig.—One pill night and morning for a month.
     Use.—In cases of tinnitus.

446

INDEX

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