

A Survey Of Surgical Procedures For The Relief of Deafness Due To Otosclerosis

D. R. HAYNES, M.B., B.Ch., (Rand), D.L.O. (R.C.P. & S.)

Ear, Nose and Throat Surgeon

The history of otosclerosis is of interest and importance for the appreciation of modern surgical techniques. More than in any other branch of surgery is the technique and its meticulous execution able to determine the difference between success and failure in restoring hearing to the sufferer from the stapes-fixing process of otosclerosis. Modern operations on the temporal bone depend fundamentally on a knowledge of the anatomy of this intricate part of the body and I think it is safe to say that more has been learnt of the physiology of hearing since Lempert established the fenestration operation than we knew before.

The anatomy of the ear is most easily understood if represented diagrammatically and the accompanying sketches attempt this. For the convenience of describing the physiology of hearing, the anatomy is divided into three parts — the outer, the middle and the inner ears. The inner ear consists of the acoustic nerve endings and it is sufficient here to say that from the point of view of the surgery of otosclerosis the acoustic nerve must be intact before surgery can hope to succeed.

FIGURE 1

The middle ear consists of three small bones or ossicles which form a chain connecting the drum membrane with the oval window. By this means, sound vibrations which enter the outer ear are transmitted from the tympanic membrane via the ossicular chain to the oval window. The smallest of the three ossicles, the stapes or stirrup, consists of two legs or crura attached to an oval plate which is capable of moving like a trapdoor in the oval window. The trapdoor is hinged at its posterior end and the maximum excursions take place at the anterior end. It is important to appreciate this fact as will be seen when the pathology of otosclerosis is discussed.

Since the inner ear is filled with fluid and this is incompressible, vibrations of the stapes footplate require an outlet and this is provided by another window covered by a membrane and known as the round window.

Normally, sound waves enter the external ear canal and produce vibrations of the tympanic membrane. These are in turn transmitted through the ossicular chain to the oval window where vibrations are set

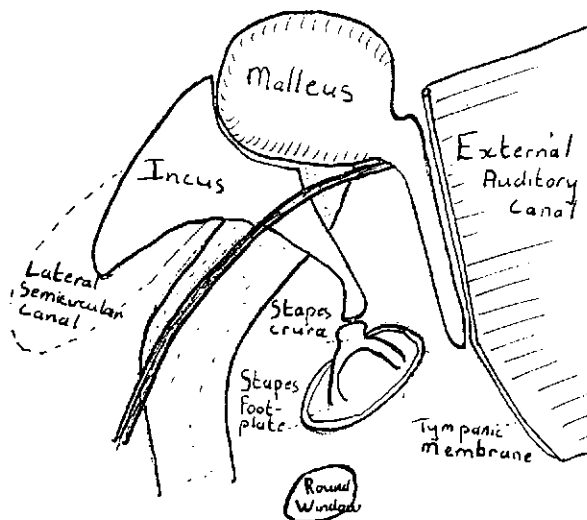


Fig. 1

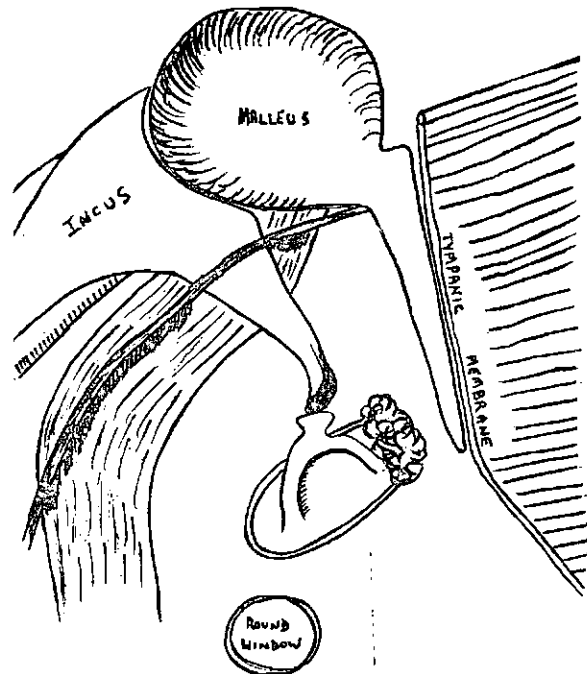


Fig. 2

OTOSCLEROSIS

in motion in the fluid of the inner ear. It is these vibrations that stimulate the nerve endings in the inner ear and impulses are conveyed to the brain.

FIGURE 2

In the condition known as otosclerosis, there is an overgrowth of spongy bone starting at the anterior end of the oval window and progressively involving the neighbouring structures. When the spongy bone encroaches on the footplate of the stapes, this structure becomes fixed and, as a result, is prevented from transmitting sound vibrations brought to it by the ossicular chain. As the condition progresses, the whole of the footplate may be involved and even the posterior end may become fixed although, as mentioned above, maximum movement takes place at the anterior end and it is here that the condition produces its maximum interference with hearing.

Versalius first described the two larger bones in the middle ear cavity in the sixteenth century and the stapes was described by Ingrassia at a later date. It says a great deal for the observational powers of Val-salva that he described fixation of the stapes as long ago as 1735 and we may be sure that his observation was not assisted in any way by any of the instruments that we consider essential for this type of miniature anatomy at the present time. It was more than a century later that Toynbee recognised stapes anky-losis to be the cause of deafness and although his observations were not accepted without misgivings and reluctance by many of his colleagues, we have records of attempts to mobilize the stapes footplates for the relief of deafness in 1878. The first operations failed because of re-fixation of the ossicle and in 1897 Passouw tried to by-pass the oval window by making a fenestra in the promontory but surgical procedures in this region were considered to be unjustified for the relief of deafness because of the risk of infection of the inner ear and secondary infection of the cranial cavity.

In 1913 Jenkins by-passed the oval window by creating a fenestra in the lateral semicircular canal and obtained an immediate improvement in hearing which unfortunately was short-lived. Once again the Surgeons were up against the serious risk of uncontrollable infection. Modifications in technique and the advent of antibiotics led eventually to the revolutionary one-stage fenestration nov-ovalis of Dr. Julius Lempert whose tenacity of purpose triumphed over the tremendous opposition of his fellow-otologists all over the world and established surgery of the aural labyrinth on a firm footing. Not only did his work indicate surgical possibilities with the use of modern

lighting and magnification but it also led to the refutation of many of the previously held theories of the physiology of hearing and enabled great advances to be made in the field of audiology. The ramifications of these advances are almost limitless and when one begins to speculate on the newly charted seas of otology since Lempert's first successful fenestration operation in 1938, the magnitude of his contribution to the world at large can be to a small extent appre-ciated.

FIGURE 3

The Lempert fenestration operation by-passed the fixed foot-plate of the stapes and a new fenestra was made in the lateral semi-circular canal. The new fenestra was then covered by a flap of tissue consisting of the skin of the external canal attached to the tympanic membrane and in order to obtain the most perfect application of this tissue to the new fenestra the incus and the head of the malleus were removed. Since the oval window was being by-passed, the ossi-cular chain was of course not required for its normal physiological function but because the mechanical advantage of the chain was lost the ultimate hearing level was also depressed to a small extent below normal.

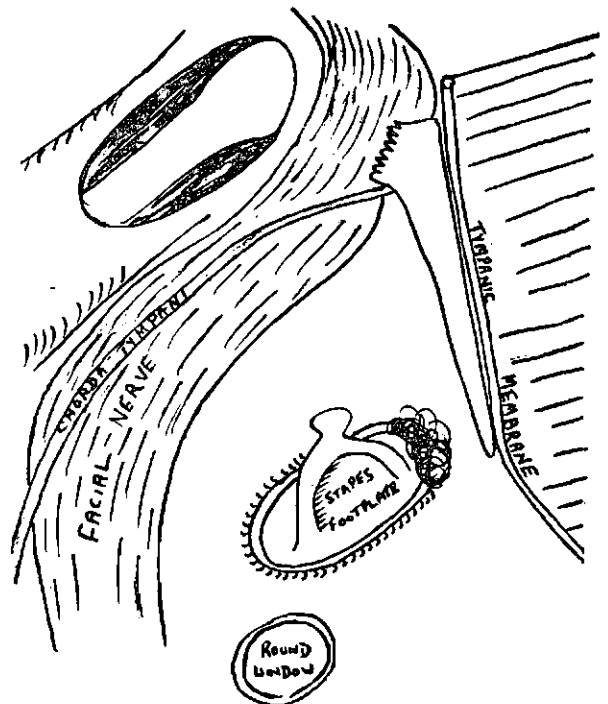


Fig. 3

FENESTRATION

The fenestration operation reached a very high peak of technical perfection and the indications for operation were worked out to such a fine degree that predictions on the ultimate result could be given with a great degree of accuracy.

In 1952, Samuel Rosen, employing the fundamental techniques of Lempert, revived the operation for stapes mobilization and obtained considerable success. Modifications were not long in appearing and because the operation was rapidly completed with very little discomfort to the patient it naturally had a tremendous appeal to the victims of otosclerosis. Experience has shown that of all the stapes mobilization operations undertaken only 30 to 40 per cent can be anticipated to give good permanent results. As experience has increased in this operation, more and more hazards have come to light but in many cases it has been found that if the procedure is not successful or re-fixation of the stapes footplate occurs, further surgery may be undertaken. In those cases that failed after an initial improvement in hearing, Rosen sometimes perforates the promontory and this procedure gives a very temporary improvement in some cases.

FIGURE 4

The operation for Stapes Mobilization is performed through the external ear canal and part of the skin of the canal attached to the tympanic membrane is elevated and reflected forwards. This exposes the middle ear cavity with its ossicles and the foot-plate of the stapes may be examined directly.

Mobilization can be effected by inserting a needle into the head of the stapes and rocking it back and forth until the adhesions of otosclerotic bone around the footplate are broken down.

If this procedure does not succeed, mobilization of the footplate is achieved by exerting pressure on the footplate directly. It may be necessary in some cases to use a small chisel to break down a large focus of spongy bone around the anterior part of the window. When mobilization has been successfully achieved, it is usually possible to see the round window reflex. This consists of movement of the round window membrane on applying pressure to the stapes footplate. When 60 per cent of mobilized stapes began to re-fix, it became obvious that the mobilization operation would have to be altered while the principle of maintaining the anatomy of the middle ear should be adhered to. For those cases in which the otosclerotic process was confined to the anterior edge of the stapes footplate, Fowler amputated the anterior crus of the stapes and fractured the footplate across its centre. The ossicular chain was in this manner maintained

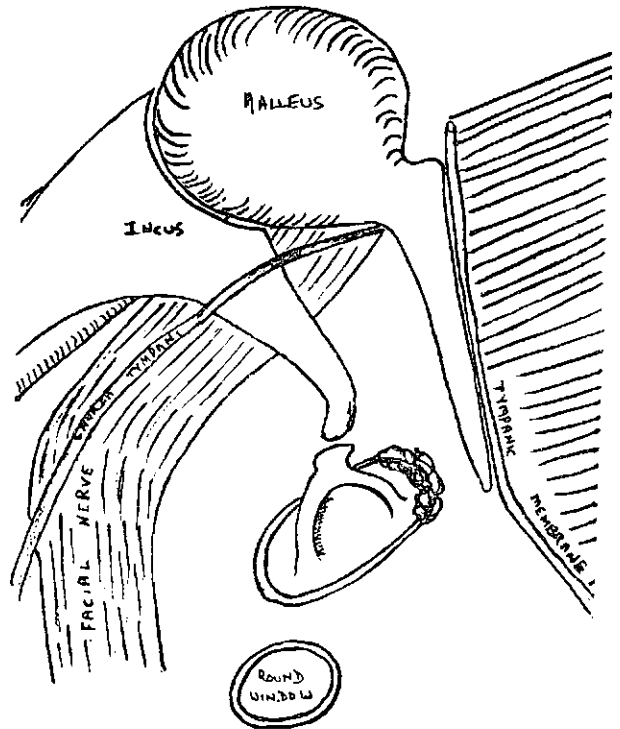


Fig. 4 STAPES MOBILIZATION

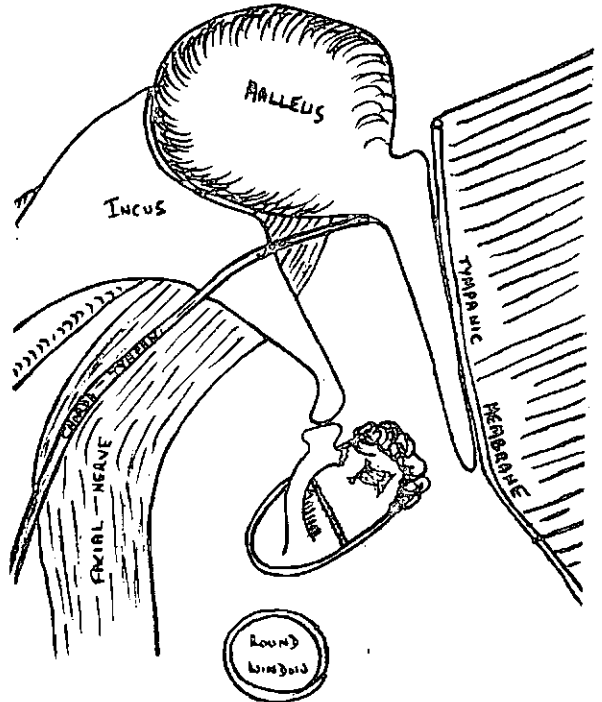


Fig. 5 ANTERIOR CRUROTOMY

and vibrations could be transmitted through the posterior crus of the stapes. The operation is known as an anterior crurotomy. It gave a higher percentage of permanently successful results than the operation for stapes mobilization.

FIGURE 5

John Shea, Jr., of Memphis, Tennessee, discussed the general principles of stapes mobilization with his orthopaedic colleagues and concluded that the procedures suggested up to that time were unphysiological and doomed for the most part to failure. He then decided to remove the pathological stapes and its footplate and replace them with prostheses. The oval window was considered to be the natural pathway for the transmission of sound waves to the inner ear and apart from anything else the chances of closure of a natural window in the labyrinth seemed to be smaller than the chances in the case of an artificial fenestra. Cawthorne at King's College Hospital had already attempted a modification of the Lempert fenestration using the oval window but had encountered the difficulty of obtaining good application of the tympanic membrane over the window so it was obvious that a substitute for the stapes must be found.

FIGURE 6

Shea's Stapedectomy consists of removal of the stapes with its footplate and covering the oval window with a vein graft. Connection between this and the incus is then effected by inserting a polythene tube between the articulating process of the long process of the incus and the vein graft lying over the oval window. So far, the results have shown 90 per cent success to the bone conduction level of hearing and most of the patients operated on by Shea four years ago (when the operation was first performed) have maintained their improvement.

Needless to say, the operation had hardly been shown to be successful before "improvements" were suggested embodying the sound principles of the original operation. House uses a plug of gelatin sponge suspended from the incus by a piece of stainless steel wire and projecting into the oval window. Schucknecht uses a small piece of fat or muscle cut from the ear in preference to the gelatin sponge and suspends it in a similar way in the the oval window.

FIGURE 7

Portman of Bordeaux employs a vein graft to cover the oval window and uses the patient's own posterior stapedial crus to complete the bridge between the incus and the oval window. Ruedi of Zurich removes the stapes completely and then replaces the stapes

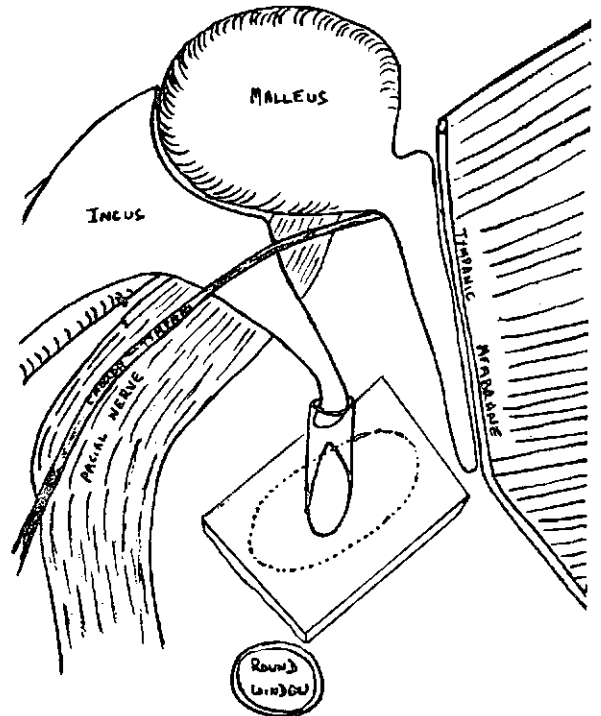


Fig. 6

SHEA STAPEDECTOMY

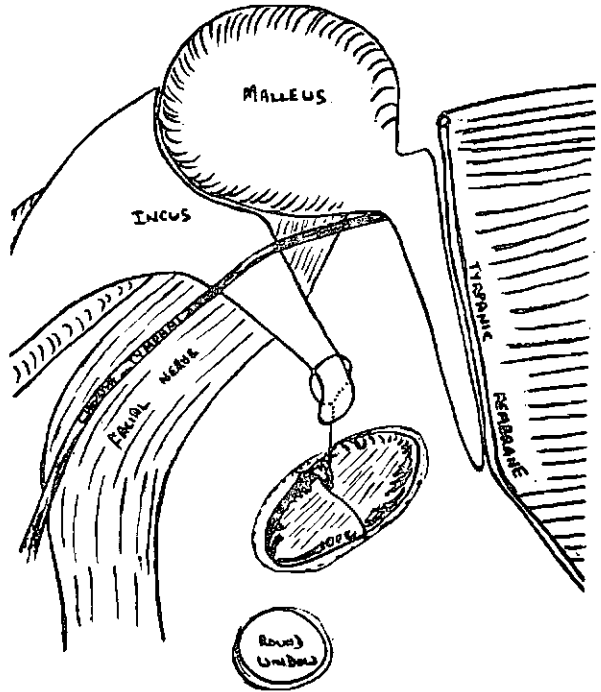


Fig. 7

SCHUCKNECHT STAPEDECTOMY

scrua together with the articulating process to act as his prosthesis. Cawthorne uses a twisted steel wire for the prosthesis bridging the stapedial gap.

FIGURE 8

Some surgeons have been pessimistic about the future of this type of surgery, but it would seem that, at the risk of the unfortunate exception suffering irreversible damage to the hearing in one ear, one must have the courage to attempt the restoration of normal hearing to the patients suffering from otosclerosis.

BOOK REVIEWS

HEARING AND DEAFNESS

HALLOWEL DAVIS and S. RICHARD SILVERMAN,
Editors

Holt, Rinehart and Winston, Inc., New York, 1960

As a new science developing from its parent studies becomes an independent speciality, a new vocabulary and literature arises. So the new word "audiology" describing the science of hearing with all its experimental and clinical implications, came into being in the mid-forties, and the need for a text like *Hearing and Deafness* edited by Hallowell Davis (1947) arose. This book served to discuss most of the aspects of hearing and the problems of deafness, and the extensive knowledge and authority of the many contributors fulfilled the criterion established by the author:

This book is written for the deaf and the hard of hearing and for their families, their parents, their teachers, and their friends. It is written for physicians, for educators, for social workers, and for all who are concerned with the conservation or improvement of remaining hearing or with the approach to normal living for those who have suffered either complete or partial hearing loss. It is written to answer the thousand and one questions that are continually being asked by all sorts of people about the nature of hearing and the problems posed by partial or complete loss of hearing.

Audiology has developed, both in depth and extent, so rapidly, and the editor of *Hearing and Deafness* is so aware of the needs created by this growth that, thirteen years after the first edition, a revised version has been published with Dr. S. Richard Silverman as co-editor to Dr. Davis.

The shift of emphasis in this edition is implicit in the omission of the sub-title "A Guide for Laymen". Although the layman with impaired hearing, or with children who are deaf or hard of hearing, will still

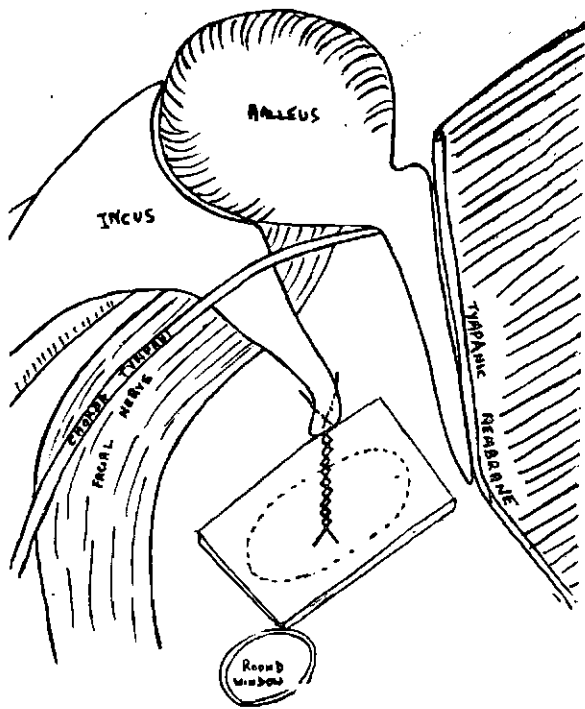


Fig. 8 CAWTHORNE STAPEDECTOMY

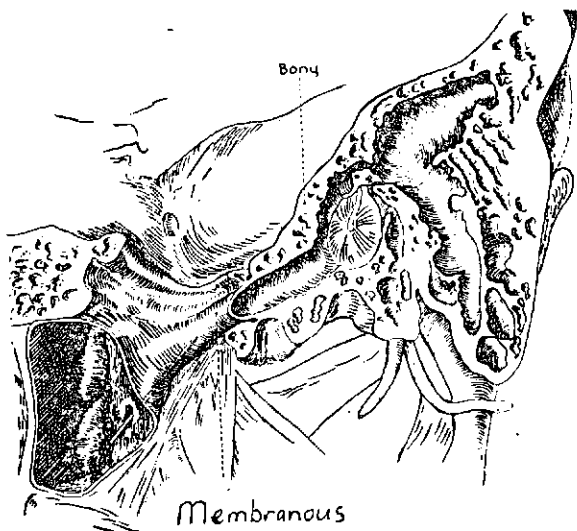


Fig. 9 THE EUSTACHIAN TUBE

A drawing from a dissection of the eustachian tube showing its relationship to the middle ear space on one end and the nasopharynx on the other end.

find the answers to his questions, the main orientation is to students of audiology, and as such, makes this text essential to those readers who, like speech therapists, come to audiology from a closely allied but differently orientated field.

As in the first edition, the sequence of the book is from inanimate nature to the individual human to complex social problems — from physical to biological to social. The editors describe this sequence as being "from physics, biology, medicine and surgery to modern studies of impaired hearing and hearing aids, and thence to special education and rehabilitation of adults with impaired hearing. The problems of the education of deaf and hard of hearing children are discussed next, and then the organised social efforts on behalf of the aurally handicapped; and finally, employment and vocational guidance." The second edition presents some new authors and aspects; and re-organization and addition of knowledge and viewpoints within the other chapters.

Some of these may be mentioned briefly as they serve to show how the altered scope of this edition has served to cover the enlarged audiological field. In his chapter on "The Physics and Psychology of Hearing", Dr. Davis introduces the concept of a threshold zone, and, while discussing anatomy and physiology of the ear, elaborates on the biophysics and physiology of the inner ear, which are now better understood. The description and causes of the various impairments of hearing have been re-organised into a new chapter, called "Hearing and Deafness", and it is here that Dr. Davis and Dr. Fowler propose a more useful set of definitions for hearing impairments than those which existed before. The chapter on the medical aspects of hearing is brought up to date by Dr. Fowler, and the rapid development of treatment and prevention provides much new material, as does the new section on hearing conservation. Surgical treatment has advanced much in the last decade, and details of the stapes mobilization, as well as the fenestration, are given by Dr. Walsh.

"Tests of Hearing" and the chapter, new in this edition, on special auditory tests, will be of the greatest practical value to speech therapists interested in audiology, as will the discussion on the rehabilitative aspects of the problem, given in the detailed and explicit chapters on hearing aids, and their choice and use, together with Dr. Miriam Pauls' section on speech reading and Dr. Carhart's on auditory training and the conservation of speech. The rehabilitative procedures with deaf and hard of hearing children are dealt with in more detail by the authors in this edition and the psychological, sociological and vocational aspects of the hearing-impaired are discussed

in the light of increased knowledge of these problems.

If the original edition was useful and informative, this edition can be considered invaluable. The thousand and one questions posed not only by the layman, but by the workers and allied professional workers in the new field, are admirably answered. *Hearing and Deafness* is a text which is indispensable to the student of audiology.

MARGARET MARKS, M.A.

STROKE. A DIARY OF RECOVERY

by DOUGLAS RITCHIE

Faber and Faber, London, 1960

174 pages

Douglas Ritchie was a well-known announcer on the B.B.C. when he suffered a severe cerebral haemorrhage in 1955. He was left with a right hemiplegia and severe aphasia. This book, started two years later, is his account of what happened to him, as he remembers it.

Although his language is of a relatively high standard, it is evident that his recovery is not complete. The narrative is at times confused, and it is difficult to see the point of certain passages.

The book is nevertheless a remarkable achievement. It is a record of the thoughts that were going through this man's mind when he was virtually speechless, and should add much to our understanding of the aphasic's feelings.

Mr. Ritchie's comments on speech therapy are revealing:-

"I liked Miss F. very much, but loathed the time I used to spend at speech therapy."

"Every student seemed to like the Reader's Digest, and I had to read the first few paragraphs of many articles".

"Miss B's influence was not confined to speech, or language re-education as one might better call it. Victims of aphasia did want to regain the power of language, but, above that, nearly all of them unconsciously craved for some emotional balance of which they had been robbed by the stroke. Ability to help in this need was Miss B's real quality."

Many aphasic patients, too, would benefit from reading the story of Mr. Ritchie's battle against great odds and his gradual adjustment to his difficulties. He also gives practical suggestions to other aphasics, and discusses some of the theoretical aspects of aphasia.

He feels that by gaining an understanding of his condition, he had a better idea of the purpose of the various therapists who were working with him.

PAT ALLSOPP.